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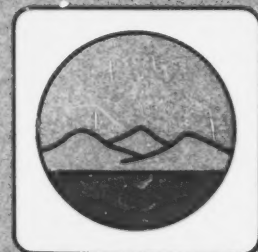
LAND USE INDICATORS OF ENVIRONMENTAL QUALITY

AN EXAMINATION OF EXISTING FEDERAL DATA
AND FUTURE NEEDS

PREPARED FOR
THE COUNCIL ON ENVIRONMENTAL QUALITY

April 15, 1972

NATIONAL TECHNICAL
INFORMATION SERVICE



EARTH SATELLITE CORPORATION

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ERRATA

LAND USE INDICATORS OF ENVIRONMENTAL QUALITY

Page 10 is a reprint of page 9.

Table 2.6.0 was omitted from the section on wetlands.

Table 2.6.0

State	Swamplands patented to States since 1850	USDA inventory of 1906	USDA inventory of 1922	Current FWS inventory ¹
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Arkansas.....	7,686,575	5,912,300	4,220,000	3,748,800
California.....	2,192,875	3,420,000	1,179,000	457,200
Florida.....	20,325,013	19,800,000	16,846,000	15,266,400
Illinois.....	1,460,164	925,000	600,000	176,700
Indiana.....	1,259,231	625,000	778,000	267,100
Iowa.....	1,196,392	930,000	368,000	117,000
Missouri.....	3,432,481	2,439,600	1,085,000	322,000
Total.....	37,552,731	34,051,900	25,076,000	20,355,200
Percent reduction since 1850.....		9.3	33.2	45.7

¹ Figures in this column do not agree with State-total figures in table 6 because acreages of open-water types are excluded in order to represent coverage similar to the 1850, 1906, and 1922 inventories.



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August 23, 1972

Dr. J. Clarence Davies, 3d
Council on Environmental Quality
722 Jackson Place, N.W.
Washington, D.C. 20006

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SUMMARY

The objective of this study was to determine whether useful indicators of environmental quality could be developed from land use data currently collected by the Federal Government. To meet this objective it was necessary to examine and evaluate existing land use data collected by the Federal Government.

Existing data proved, for the most part, to be inadequate for providing a reliable and consistent base for developing indicators of environmental quality. While numerous data are available, internal inconsistencies and the lack of compatibility from agency-to-agency seriously compromise the data. Some of the shortcomings of existing data include:

- Geographic units for which data are collected or aggregated vary among and within departments, and from survey-to-survey;
- Regular repetitive coverage such as that provided by the Decennial Census is lacking with respect to many of the data collected on land use;
- Existing data do not provide sufficient spatial information (i.e., they do not indicate the geographic relationship between different and perhaps competing uses).

Spatial information is essential for making environmental assessments. For example, the per capita acreage of open space within a metropolitan area can provide a rough measure of recreational potential. But acreage figures alone can be misleading. It makes a difference whether the open space is located in a single park which is remote from or inaccessible to a large percentage of the population, or whether open space land is fairly evenly distributed within the metropolitan area.

- Data collected by one agency are often incompatible with data collected by another agency because of the problems stated above. It is impossible, therefore, to relate data from different sources on a nationwide basis. For example, the relationship between land use and water quality, cannot be easily established with data in existing formats. Runoff from agricultural land may affect water quality, but since agricultural data are collected by county and water quality data by river basin, it is extremely difficult to provide regular and timely nationwide data on the relationship between agricultural land use and water quality using existing data formats.

Because the land use data currently being collected were found to be inadequate for developing indicators of environmental quality, the study examined the upgrading of existing data collection programs to

provide greater uniformity among data and additional information required to address environmental problems. Aerial remote sensing was examined as a possible means of improving data and it appears that supplementary remote sensing data can significantly increase the usefulness of existing data.

The study recommends:

- Adoption by the Federal Government of a standard land use classification system.
- Development of compatible data parameters and formats.
- Reliance on high altitude aerial remote sensing for gathering supplementary data on land use.
- Coordination of land use research within the Federal Government.
- Identification of environmentally distressed areas through the examination of land use data.

TABLE OF CONTENTS

- 1.0 INTRODUCTION
 - 1.1 Scope of Work
 - 1.2 Methodology
- 2.0 EVALUATION OF LAND USE DATA COLLECTED BY THE FEDERAL GOVERNMENT
 - 2.1 Agriculture
 - 2.2 Forestry
 - 2.3 Surface Mining and Surface Mine Reclamation
 - 2.4 Public Works
 - 2.5 Flood Plains
 - 2.6 Wetlands
 - 2.7 Transportation
 - 2.8 Overall Shifts in Major Categories of Land Use
- 3.0 DEVELOPMENT OF LAND USE INDICATORS OF ENVIRONMENTAL QUALITY USING EXISTING DATA
 - 3.1 Using Mixtures of Existing Data and Supplementary Data
 - 3.2 Potential Future Systems
- 4.0 CONCLUSIONS AND RECOMMENDATIONS
 - 4.1 Coordination of Environmental Data Programs by the Council on Environmental Quality
 - 4.2 Adoption of Standard Land Use Classification System

- 4.3 An Environmental Information System Relying on Existing Data and Remote Sensing
- 4.4 The Establishment of an Environmental Data Network within the Federal Government
- 4.5 The Coordination of Land Use Research
- 4.6 Identification of Environmentally Distressed Areas

APPENDICES

1.0 INTRODUCTION

The objective of this study was to develop indicators of environmental quality using to the greatest extent possible land use data currently being collected by the Federal Government. To meet this objective, it was necessary to identify and evaluate land use data currently being collected, and to examine historical data to determine whether baseline or trend information could be developed. The study examined the data collection activities of numerous agencies and analyzed large amounts of land use data collected over time. From these studies, it was apparent that existing data contained serious inadequacies when considered as components of indicators of environmental quality. These inadequacies are discussed in detail for eight land use categories in Section 2.0, and the following is a brief summary of the problems with existing data which were encountered:

- Geographic units for which data are collected or aggregated vary among and within departments, and from survey to survey;
- Regular repetitive coverage such as that provided by the Decennial Census is lacking with respect to many of the data collected on land use;
- Existing data do not provide sufficient spatial information (i.e., they do not indicate the geographic relationship between different and perhaps competing uses). Spatial information is

essential for making environmental assessments. For example, the per capita acreage of open space within a metropolitan area can provide a rough measure of recreational potential, but acreage figures alone can be misleading. It makes a difference whether open space is located in a single park which is remote from or inaccessible to a large percentage of the population, or is fairly evenly distributed within the metropolitan area.

- Data collected by one agency are often incompatible with data collected by another agency because of the problems stated above. It is impossible, therefore, to relate data from different sources on a nationwide basis. For example, the relationship between land use and water quality, cannot be easily established with data in existing formats. Runoff from agricultural land may affect water quality, but since agricultural data are collected by county and water quality data by river basin, it is extremely difficult to provide regular and timely nationwide data on the relationship between agricultural land use and water quality using existing data formats.

Having concluded that existing data were inadequate, the study was expanded by the Council on Environmental Quality and the contractor to

determine what changes in currently collected data were required, and to explore means for improving existing land use data collection programs to provide additional and more useful information. (It is important to note that when this report refers to the "adequacy" or "inadequacy" of existing data, it is judging data in terms of their usefulness as components of indicators of environmental quality. Since existing land use data are collected to meet specific statutory or administrative responsibilities not directly related to measuring the quality of the environment, they may be perfectly adequate for their intended purpose, and still be inadequate in the sense of providing useful information on the quality of the environment.)

Section 3.0 discusses some alternatives for upgrading flood plains, forestry, and urban land use data. These three categories were chosen from among the eight categories in Section 2.0 because they represent (1) a category for which very little land use data is available (flood plains); (2) a category for which a well ordered systematic data collection program exists (forestry); and (3) a category for which there are large amounts of data, but those data contain serious inadequacies (urban land use). Aerial remote sensing is the principal means of upgrading existing data discussed in Section 3.0. Section 3.1.3 discusses some of the costs for providing aerial remote sensing data for a large metropolitan area. It was concluded that in order to develop meaningful indicators of environmental quality based on land use data for urban areas required substantially the same kinds of data required for general urban planning. The relative value of the various kinds of data may differ when trying to

measure the quality of the environment, but the data required are by-and-large the same.

In examining ways and means of upgrading existing data, it was attempted to keep modifications and costs to a minimum.

Before the quality of the environment can be measured, certain value judgments must be made. The making of such judgments was from the outset specifically excluded from this study. While societal environmental values may in the end determine whether an activity is permitted on the land, it is apparent from this study that just to know more about what is happening with respect to land use whether "good" or "bad" would be a significant step toward more meaningful environmental planning.

Section 4.0 contains the findings and recommendations of this study. Included are recommendations for upgrading existing data and providing additional data, which is a prerequisite to developing reliable indicators of environmental quality based on land use, and recommendations as to how land use data can be more usefully employed in assessing and monitoring the environment.

1.1 Scope of Work

The scope of this study was influenced by the following:

(1) Land use indicators of environmental quality should be based "to the greatest extent possible...on existing data collection systems." This required both (a) thorough examination of existing programs, (b) the consideration of additional ways of providing the traditional data required by individual agencies, and (c) evaluation of data suitable for decisions on environmental quality.

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(2) In setting forth the general requirements for land use/environmental quality information, no attempt has been made to describe specific legal, administrative and technical machinery necessary to initiate new data acquisition.

(3) Types of land use data which would aid decisions on policy and programming in environmental quality are generally and qualitatively described. Parameters such as collection frequency, level of detail, the use of sampling techniques, accuracy, and scale are discussed. However, the data which are available do not lend themselves to a strict statistical measure such as "confidence interval," with respect to their value as indicators of environmental quality. We give instead, qualitative evaluations where required.

The question of identifying and developing land use indicators of environmental quality has been examined. In the time available, with data of questionable value, it has not proved feasible to develop such indicators.

1.1.0 Indicators of Environmental Quality

Study objectives included the development of land use indicators of environmental quality. These indicators were to be derived from existing land use data collected by the Federal Government to the greatest extent possible. Certain indicators, principally changes in acreage, have been discussed in Section 2.0. However, no "indicators" per se have been developed at this time for reasons which are discussed later in this report. The indicators deal with broad classes of land use.

In some cases, simple data on areal changes are sufficient to indicate changes in environmental quality. For example, any loss in coastal wetlands, whether for vacation housing or industrial development, represents a significant environmental change. It does not matter where these wetlands were located, what adjacent land uses might have been, or to what new use the land has been put. An absolute and probably irreversible loss to the coastal ecology has occurred. It is not as easy to assess areal changes in farm land or forests, though simple areal data can be useful. For example: In addition to knowing where farm or forest acreage is lost, it is important to also know the nature of adjacent land uses, to know what are the new uses of land, and what, if any, compensating actions are being taken.

1.1.1 Definitions

The following definitions were adopted both to limit the scope of the investigation and to assure consistency in discussions, reports and recommendations. These definitions are reasonably consistent with general use.

Areal data:

The area devoted to a particular "land use" given as acres and square miles.

Change detection:

The discovery and analysis of changes in land use in terms of both degree and kind of land use. Predictive techniques may be used.

Land use:

Land use is a complex term which incorporates activity on the land, its ownership, intensity of use, quality of development, restrictions, etc. For the purpose of this report, land use refers to the activity on the parcel of land.

Land use indicator of environmental quality:

An indicator employing land use data which provides a useful and periodic measure of the state of the environment when analyzed separately or with other data.

Land use/environmental
quality information system:

A data system which collects, processes and disseminates land use data and information related directly to the state of the environment or which can be used with other data to assess the state of the environment.

Remote sensing:

The acquisition of data from aircraft and satellite platforms using imaging and non-imaging electromagnetic systems. These include, but are not limited to, photographic systems, multi-channel scanners, and active microwave systems.

Spatial relationships:

The way in which land use units are distributed in space with respect to their sizes, interfaces and complex intermingling with adjacent land use.

1.1.2 Land Use Classification Systems

Many Federal and state agencies collect land use data. These data meet administrative and/or legal requirements and are principally used to implement specific programs. Definitions differ greatly from agency to agency. For example, what constitutes forest or urban land according to the Department of Agriculture, may not constitute forest or urban land to the Department of Housing and Urban Development. Worthwhile efforts have been made to standardize definitions among agencies and many inconsistencies have been eliminated. Resolution of remaining differences and the uniform application of such a system are needed to increase the usefulness of existing data.

The adoption of a standard land use classification by the Federal Government is absolutely essential to the development of a land use/environmental quality information system. The leadership of the Geographic Applications Program of the Department of the Interior is currently considering the adoption of such a system.

Numerous land use classification systems have been used in this country. Minnesota and New York State have undertaken land use classification programs which rely on remote sensing. In 1965, the Bureau of Public Roads and the

Urban Renewal Administration published the Standard Land Use Coding Manual which is still being used today by the Department of Transportation.^{1/} A more recent publication of the Department of Housing and Urban Development proposes a classification specifically for urban metropolitan areas.^{2/} The National Inventory of Conservation Needs^{3/} of the Department of Agriculture contains yet another classification scheme. Smaller communities often find the Standard Land Use Coding Manual too detailed for their needs and many use "Planning Maps for Small Cities," which is published by the American Society of Planning Officials.

The following is a brief discussion of some classification systems to indicate the range encountered.

The Standard Land Use Coding Manual is widely used by local governments. Land use data for standard metropolitan statistical areas is prepared using this manual as a guide to satisfy the continuing planning requirements of the Federal Highway Act of 1962, and the Urban Planning Assistance Program. The system is a four digit one, and the Manual provides detailed information for local enumerators for each level of detail. Unfortunately, the system is not required by either agency, and according to the Department of Transportation, local governments modify it to meet local needs.

Metropolitan Planning Data for Local Governments: A Demonstration of Land Use Compatibility is a different answer to the question of providing land use data for metropolitan government to meet Federal

- 1/ Standard Land Use Coding Manual, Urban Renewal Administration and Bureau of Public Roads, 1965, Washington, D. C.
- 2/ Metropolitan Planning Data from Local Governments: A Demonstration of Land Use Compatibility, 1970. Metropolitan Washington Council of Governments.
- 3/ The National Inventory of Conservation Needs, U. S. Department of Agriculture, 1967.

program requirements. This system was developed as part of a demonstration project, and does not carry the endorsement of the Department of Housing and Urban Development which funded the project. Because of the success of the project and the widespread circulation of the report, it may, however, be adopted by other regional organizations. This system goes beyond the Standard Land Use Coding Manual by adding to activity data, such as zoning restrictions, location, ownership, and intensity of use. Such additional land use data are valuable to local government, though probably for the foreseeable future, of little immediate interest to the Federal Government.

The Minnesota Land Management Information Study, now in press, uses a simple nine-category classification of land use data developed using aerial photography. Each 40 acre cell in the State was categorized into one of the following nine classes: Forested, cultivated, pasture and open, water, marsh, urban residential, urban non-residential, extractive and transportation. This system has some value in providing detailed spatial information of these nine broad classes for state planning purposes. However, it will be of distinctly less utility at the region and county level which requires finer categorization and possibly finer spatial subdivision.

The New York State Land Use and Natural Resources Inventory uses a very complex classification system which provides both areal and point data. Aerial photography (1:24,000 scale) was the principal source of data. The system was developed by the Center for

Aerial Photographic Studies of Cornell University and was intended to accommodate automated data processing, including the printing of digitized land use maps. One hundred and nineteen classes are provided for (areal 50, point 69).

Standardizing definitions among such a wide variety of classification systems will be difficult. Whatever the form which standardization takes, the following should be considered:

- The system should allow for 3 or 4 levels of detail.
- Detailed data from lower levels should be capable of being aggregated upward.
- This classification system should assure that data traditionally collected by Federal agencies to meet their responsibilities, are provided in a useable form.
- The classification system should anticipate the use of remote sensing for part of the data acquisition and the use of computers for data processing analysis and dissemination.

1.2 Methodology

The work program is summarized in Figure 1.2.0 and the table of organization in Figure 1.2.1. The collection of data on land use from Federal sources took far longer than was anticipated. In addition to the nationwide and regional historical data described in Section 2.0, numerous other national surveys and local studies were examined. Included in this report are those which we judge to be the most useful and informative.

Meetings and numerous telephone conversations with Federal officials provided a basic mechanism for identifying historical data, exploring existing information systems, Federal agency use of remote sensing, and most important, for exploring the possibilities of new and/or expanded information programs.

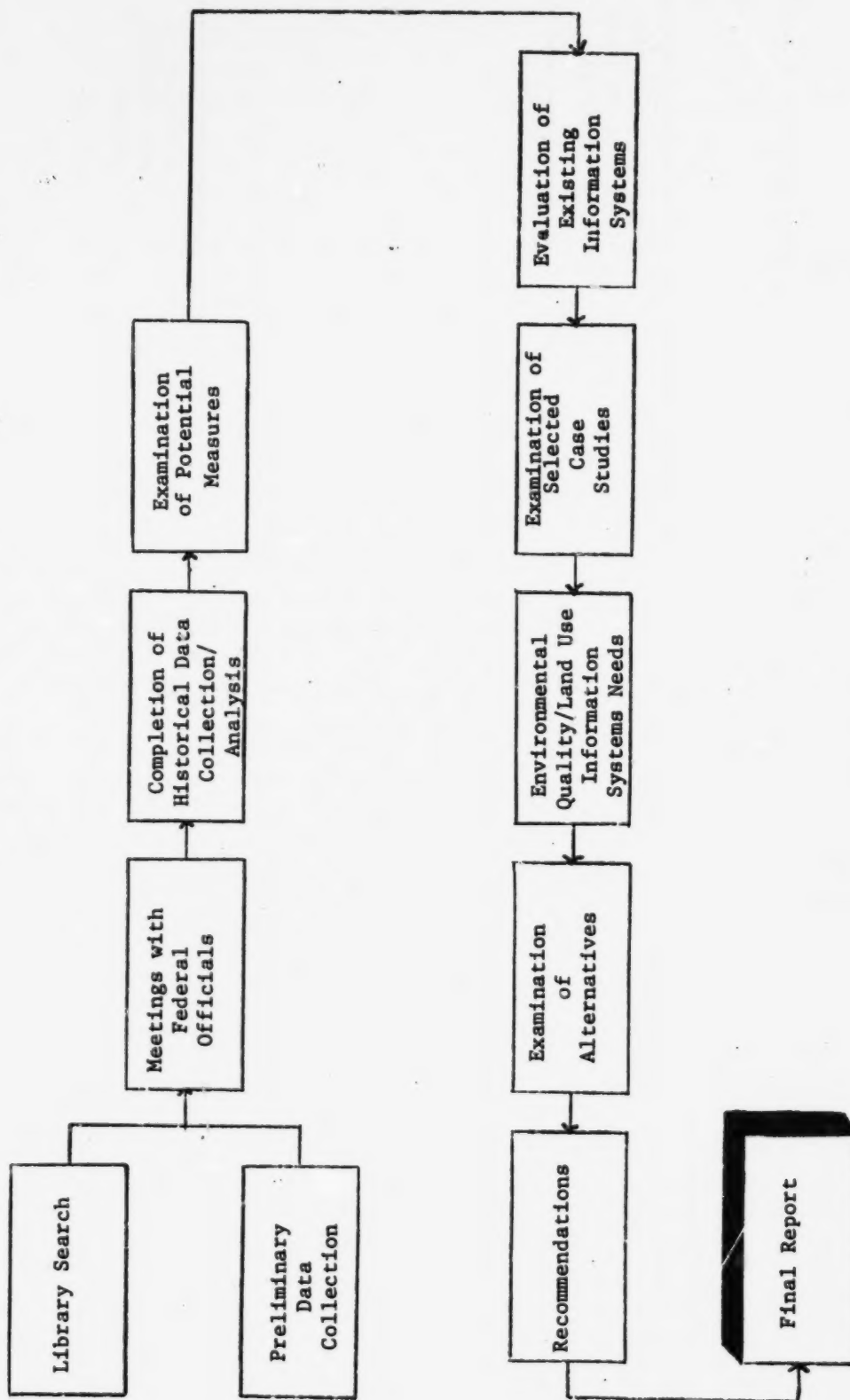


Figure 1.2.0 - LAND USE DATA STUDY TASK DIAGRAM

ORGANIZATION CHART

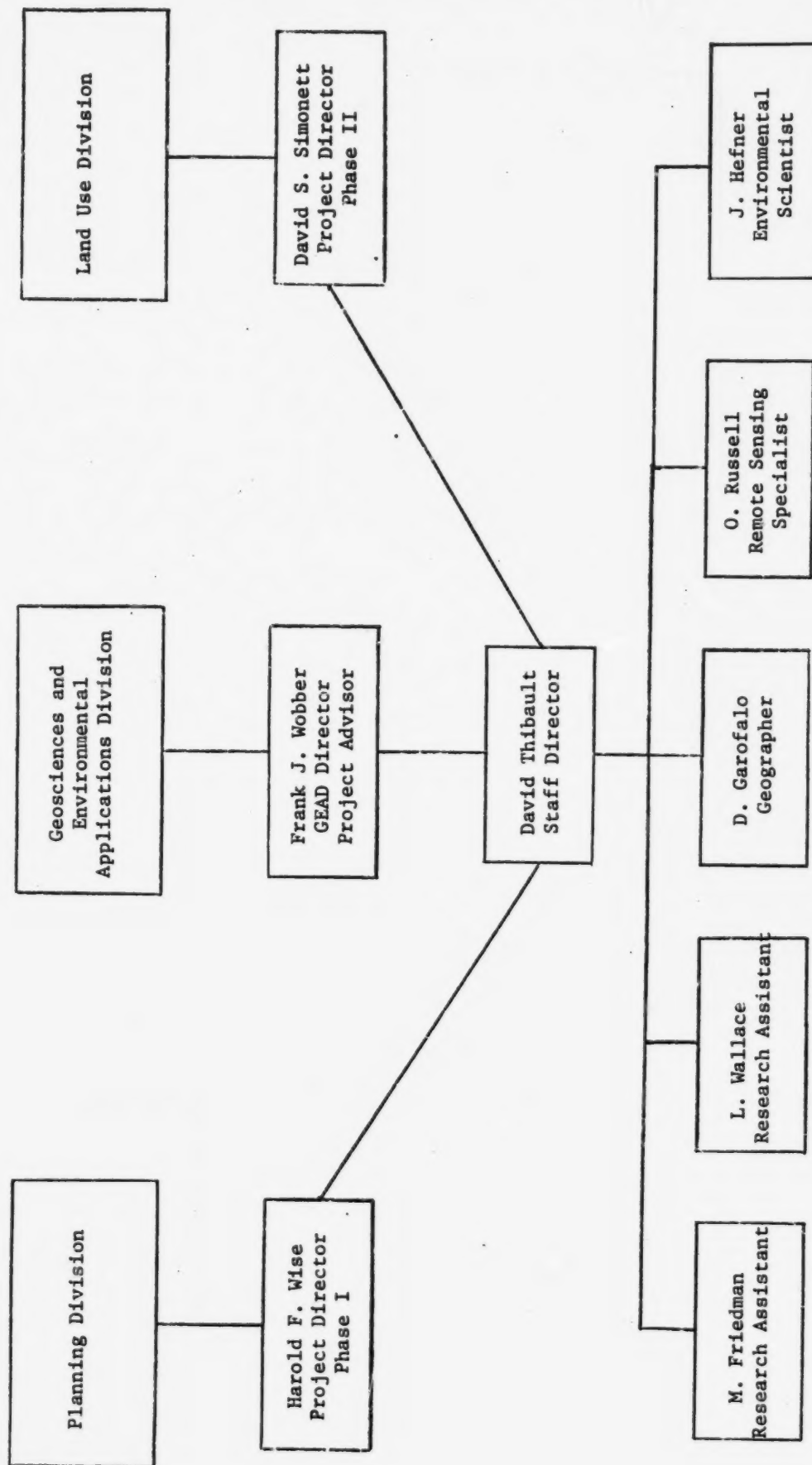


Figure 1.2.1

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The identification and evaluation of potential indicators proved especially difficult and a continual process of confronting unsatisfactory data.

In evaluating the future data needs of the Federal Government, EarthSat gave attention only to environmental data. The staff relied upon discussions with Federal officials, and in part, on the requirement for environmental impact statements contained in the Environmental Quality Act of 1969.

Data processing systems were not examined, though determinations were made as to whether automated systems are employed or under consideration.

The examples discussed throughout the report, draw upon an evaluation of existing case histories which were judged by EarthSat staff to illustrate the diversity and complexity of drawing environmental conclusions from existing land use data.

2.0 EVALUATION OF LAND USE DATA COLLECTED BY THE FEDERAL GOVERNMENT

The section will examine the historical data available on land use, assess the potential of these data for indicating environmental quality, and recommend specific kinds of data required to develop indicators for a land use/environmental quality information system. The categories of land use and the order in which they will be discussed are as follows:

- Agriculture
- Forestry
- Strip Mining
- Public Works
- Flood Plains
- Wetlands
- Transportation
- Overall Shifts in Land Use

While urban land use was not identified as a separate category in the work statement, data on urban land use are included in various sections.

The categories are not mutually exclusive, but neither are the data collected nor the programs administered by the various Federal agencies.

2.1 Agriculture

More data are available on land used for agriculture than for any other category. Historical data are available for all of the nation's area. These land use data are of varying utility for indicating environmental quality and environmental change. Because many of these data have been collected at regular intervals over extended periods of time they can, however, provide valuable historical and baseline information for a land use/environmental quality information system. Since many of these data are

required for the administration of the Department of Agriculture (USDA) programs, their collection is likely to continue. The potential value of these data in a land use/environmental quality information system has been examined because of the likelihood that they will be available at little or no additional cost to the Federal Government. Appendix I contains additional information on agricultural land use data.

USDA statistics on crop production have sufficient detail to provide useful information on environmental quality if they are collected and available in the proper time frame. For example, acres planted and acres harvested could be used as an indicator of areas of environmental stress, such as drought. (There are, of course, other factors and possible causes.) Data intended to warn of acute stresses on the environment must be timely if they are to be functional.

Some of the data collected by or for the USDA provided useful information on environmental quality in their present form. Most of the data are published as areal tables, such as acres of given crops per county, state and region.^{1/} Some examples of the historical areal data are described below.

^{1/} The Department also conducts a major aerial photographic acquisition program designed principally for monitoring compliance with set aside programs. It is estimated by the USDA that 576,000 square miles were photographed in 1971 or about 20% of the U.S. land area.

Tables 2.1.0 and 2.1.1 show nationwide data on the agricultural and non-agricultural uses of land. Table 2.1.0 provides a general summary of land use changes from 1950-1964. Table 2.1.1 is an elaboration on the data contained in Table 2.1.0 for the year 1964. These data are nationwide aggregations; the data are also available by region,^{2/} by state, and in most instances, by counties. They are assembled from a wide variety of sources by the Economic Research Service of the Department of Agriculture as part of a land use study conducted at 5-year intervals.^{3/} While every effort has been made to keep data comparable from one survey to the next, there are instances where estimates have to be made, where state data are inadequate, and/or where apparent changes from one survey to the next result from changing definitions rather than changing land use. The summary tables are well footnoted and definitional and procedural changes from survey-to-survey are well documented.

Table 2.1.0 deals with cropland acreages during the period 1950 to 1964. During the period there has been a relatively steady decrease in the amount of farmed cropland in the U.S., such that in 1964 7.1% less land was farmed than in 1950. Interpretation of the significance of this change in terms of environmental quality can prove difficult. In particular some of the decline in acreage probably resulted from the diversion of agricultural land to other uses such as surface mining or heavy industry which may have greater adverse affects on the environment. The land may also have been

^{2/} The regions are as follows: Northeast, 11 states and the District of Columbia; Lake States, 3 states; Corn Belt, 5 states; Northern Plains, 4 states; Appalachian, 5 states; Southeast, 4 states; Delta, 3 states; Southern Plains, 2 states; Mountain, 8 states; Pacific, 3 states; and Alaska and Hawaii.

^{3/} Major Uses of Land and Water in the United States with Special Reference to Agriculture - Summary for 1964, U.S. Department of Agriculture, Economic Research Service, 1968.

TABLE 2.1.0 -- Trends in Major Uses of Land, United States, 1950-64*

Land Use	1950	1954	% Change	1959	% Change	1964	% Change	% Change 1950-64
	----- Million Acres -----							-----
Cropland ^{1/}	478	466	(4.6)	458	(1.7)	444	(3.2)	(7.1)
Grassland pasture and range ^{2/}	632	634	.3	633	(.2)	640	1.1	1.3
Forest land ^{3/}	740	745	.7	747	.3	732	(2.0)	(1.0)
(grazed)	(319)	(301)	(5.6)	(245)	(18.6)	(225)	(8.1)	(29.5)
Special areas ^{4/}	138	143	3.6	157	9.0	173	10.2	25.4
Miscellaneous other land ^{5/}	285	285	0	276	(3.2)	277	.4	(2.9)
Total ^{6/}	2,273	2,273		2,271		2,266		

1/ Cropland harvested, crop failure, cropland idle or fallow, and cropland used only for pasture.
Cropland and pasture acreages for 1950 relate to the previous year.

2/ Grassland and other nonforested pasture and range.

3/ Exclusive of forest land in parks, wildlife refuges, and other special use areas.

4/ Includes such uses as urban areas, highways and roads, parks, wildlife areas, military reservations, and farmsteads.

5/ Includes deserts, swamps, bare rock, tundra, and similar areas generally having low value for agricultural purposes.

6/ Decreases in the land area mainly represent increases in the water area of artificial reservoirs. Changes in methods of area measurement used by the Bureau of the Census together with revisions for Alaska also account for much of the decrease after 1959.

* Source: Adopted with modification from Major Uses of Land and Water in the United States with Special Reference to Agriculture Summary of 1964 - U. S. Department of Agriculture, Economic Research Service, 1968. (The % Change columns were added by EarthSat.)

converted to recreational areas (i.e., golf courses and new vacation communities may have environmental benefits not found in farms). It is more likely that housing and commerce have been the principal occupants of former cropland. Regardless of the change, it is not sufficient to know that a change has occurred, and much of the areal data on agriculture tells little more.

Table 2.1.1 deals with land use at a very gross level of generalization. Thus, the agricultural uses are broken into cropland, grassland pasture and range, woodland graze, farmsteads and farm roads. Similarly, nonagricultural land use is divided into forest land not grazed, special uses and other land. This level of aggregation produces data which are almost meaningless for indicators of environmental quality. Since the data may, however, be disaggregated in most cases to the county level and since they are available historically, they may, at different levels of regional aggregation, serve as a useful indicator of environmental change.

Tables 2.1.2 and 2.1.3 are regional aggregations of data on land use collected, analyzed, and published by the USDA. These data are also available in most instances by state and county. Table 2.1.2 shows the number of acres devoted to four principal land uses, and divides 48 contiguous states into 10 regions. The data cover 1964. Similar, though not identical, data are available at five year intervals back to 1945. These data are useful both for comparing in very gross terms the allocations of land by region, for determining trends within regions, and for comparing trends from region-to-region. These data do not, nor do successive disaggregations of these data, identify points where changes are

TABLE 2.1.1. -- Major Uses of Land in Farms and Not in Farms,
United States, 1964*

Major Use	Land in farms		Land not in farms		Total
	Acreage	Percent- age of total	Acreage	Percent- age of total	Acreage
	Million acres	Percent	Million acres	Percent	Million acres
Agricultural uses of land:					
Cropland-----	444	100	---	---	444
Grassland pasture and range:	490	77	150	23	640
Woodland grazed-----	82	36	143	64	225
Farmsteads, farm roads-----	9	100	---	---	9
Total agricultural land--	1,025	78	293	22	1,318
Nonagricultural land:					
Forest land not grazed-----	64	13	443	87	507
Special uses-----	---	---	164	100	164
Other land-----	21	8	256	92	277
Total nonagricultural land:	85	9	863	91	948
Total land area	1,110	49	1,156	51	2,266

* Source: U. S. Department of Agriculture

Major Uses of Land and Water in the United States with Special
Reference to Agriculture, Summary for 1964.

TABLE 2.1.2 -- Major Uses of Land by Regions, United States, 1964.

Regions	Cropland 1/			Pasture and range 2/			Forest land 3/			Other land 4/			Approximate land area 5/		
	Acreage	Percent of total	Percent	Acreage	Percent of total	Percent	Acreage	Percent of total	Percent	Acreage	Percent of total	Percent	Acreage	Percent of total	Percent
	1,000 acres		Percent	1,000 acres		Percent	1,000 acres		Percent	1,000 acres		Percent	1,000 acres		Percent
Northeast-----	19,173	17		7,110	6		66,637	60		19,303	17		112,223	100	
Lake States-----	44,970	37		8,485	7		53,417	44		15,094	12		121,966	100	
Corn Belt-----	94,750	57		20,335	12		30,407	19		19,737	12		165,229	100	
Northern Plains--	98,843	51		80,675	41		4,244	2		10,679	6		194,441	100	
Appalachian-----	28,883	23		10,778	9		73,021	59		11,493	9		124,175	100	
Southeast-----	18,880	15		12,564	10		78,992	64		13,381	11		123,817	100	
Delta States-----	20,238	22		9,433	10		54,624	59		8,305	9		92,600	100	
Southern Plains--	49,446	23		118,378	56		33,071	16		11,556	5		212,451	100	
Mountain-----	43,167	8		314,399	57		127,591	23		63,088	12		548,245	100	
Pacific-----	25,451	12		54,307	27		89,819	44		34,845	17		204,422	100	
48 States-----	443,801	23		636,464	34		611,823	32		207,481	11		1,899,569	100	
Alaska-----	24	6/		2,772	1		118,156	32		241,565	67		362,517	100	
Hawaii-----	371	9		1,203	29		1,796	43		817	19		4,187	100	
U. S. Total--	444,196	20		640,439	28		731,775	32		449,863	20		2,266,273	100	

1/ Includes cropland harvested, idle, and used only for pasture; crop failure, cultivated summer fallow, and soil-improvement crops.

2/ Includes open permanent pasture in farms and grassland range not in farms.

3/ Total forest land area as reported by the U. S. Forest Service, preliminary table, September 1967, excluding reserved woodland and forest areas in National and State parks and other special use areas. Because of multiple use, some overlaps occur in acreages between forest land, special use, and other areas that were not feasible to eliminate.

4/ Includes cities and towns of 1,000 or more population, highway and railroad rights-of-way, airports, National and State parks, wildlife refuges, wilderness areas, national defense lands, Federal flood-control areas, farmsteads, feedlots, ditches, farm roads and lanes, swamps, bare rock, deserts, and tundra.

5/ Remeasurement after the 1960 census showed land area of 1,900 million acres for the 48 contiguous States, and 2,266 million acres for the Nation.

6/ Less than 0.5 percent.

Source: Major Uses of Land and Water in the United States with Special Reference to Agriculture, Summary for 1964.

TABLE 2.1.3 -- Cropland Used for Crops, by Regions, 1950-66^{1/}

Year	North- east	Lake States	Corn Belt	Northern Plains	Appa- lachian	South- east	Delta States	Southern Plains	Mountain	Pacific	48 States
-----Million acres-----											
1950----	17.1	37.5	77.2	93.3	21.1	18.7	15.3	41.7	35.2	20.2	377.3
1951----	17.0	37.7	77.4	93.8	21.2	18.7	15.4	43.4	35.9	20.6	381.1
1952----	16.9	37.4	77.8	93.8	20.8	19.0	15.1	41.8	36.6	20.8	380.0
1953----	16.8	37.6	78.8	94.0	20.6	18.9	14.9	41.3	35.8	20.8	379.5
1954----	16.6	37.6	79.4	95.5	20.0	17.6	14.8	41.5	36.2	20.7	379.9
1955----	16.4	37.6	79.5	94.6	19.9	17.3	14.3	41.4	36.2	20.5	377.7
1956----	15.9	37.4	78.5	92.8	18.9	16.1	13.7	38.9	35.7	20.8	368.7
1957----	15.7	36.4	77.2	90.1	17.5	15.1	13.2	37.3	35.2	20.5	358.2
1958----	15.5	36.0	76.9	90.4	17.2	13.7	12.5	36.8	35.3	20.5	354.8
1959----	15.2	36.7	78.8	90.2	17.4	14.6	13.1	37.6	34.4	20.5	358.5
1960----	14.9	35.8	78.4	91.5	17.1	13.3	12.8	37.2	34.1	20.2	355.3
1961----	14.5	35.3	71.6	86.9	16.1	12.7	12.8	35.8	33.8	20.1	339.6
1962----	14.2	33.3	70.7	85.3	15.4	11.9	12.7	34.4	33.9	19.4	331.2
1963----	14.2	34.5	72.5	87.1	15.2	12.1	13.1	34.8	34.0	19.8	337.3
1964----	14.0	34.3	72.0	86.2	15.0	11.9	13.5	34.1	33.9	19.9	334.8
1965----	13.8	34.1	72.7	86.8	14.8	11.3	13.6	34.8	34.5	20.0	336.4
1966 2/-	13.8	33.5	72.6	86.0	14.7	10.5	13.5	32.5	33.9	19.9	330.9

^{1/} Cropland used is the sum of the acreage of land from which one or more crops were harvested plus
acres of crop failure and summer fallow.

^{2/} Preliminary.

Source: Major Uses of Land and Water in the United States with
Special Reference to Agriculture, Summary for 1964.

taking place. Table 2.1.3 shows annual changes in land use between 1950 and 1966 for one of the four major categories listed in Table 2.1.2,^{4/} cropland. In the Northeast, Table 2.1.3 shows a decrease of 3.3 million acres (19%) in cropland used for crops during the 17 year period. A decrease of 8.2 million acres (44%) is shown for the Southeast. In no region is an increase shown, and the nationwide (48 states) decrease over the period is 46.4 million acres (12.3%). This kind of information is useful for showing broad changes in land use. It is not, however, sufficient as an indicator of environmental quality. In addition to knowing the location of lands being taken from agricultural production, data is required which shows the land's agricultural value, the new use of the land lost, and the character of adjacent land uses. More than 500,000 acres of agricultural land is being converted to urban (as defined by USDA) uses annually.^{5/} Rapid changes in the "rural-urban fringe" have in some areas replaced highly productive agricultural activities. In other areas, marginal agricultural activities have been replaced by new communities, industry, and recreational areas.

^{4/} Please note that "Cropland" in Table 2.1.2 is not the same as "Cropland used for crops" in Table 2.1.3. "Cropland" is defined to include "cropland harvested, idle, and used only for pasture; crop failure, cultivated summer fallow, and soil improvement crops." "Cropland used for crops" is "the sum of the acreage of land from which one or more crops were harvested plus acreages of crop failure and summer fallow." This is an example of a problem which is common to all of the categories of land use data we examined. Both tables were taken from the same USDA publications. The change in categories can prove confusing. If a land use/environmental data system is to be developed, "which is understandable to the general public," (Work Statement) such changes must be avoided.

The USDA does an excellent job in footnoting its tables and charts, and this should aid the knowledgeable user. However, while a particular definition or data format may be reasonable and useful to the principal or knowledgeable user, more consistency is required if the data are to be understandable to the general public.

Automated data processing is making this task an easier one.

^{5/} Conversation with USDA officials on February 9, 1972.

To evaluate the quality of the environment will be difficult with comprehensive data on land use. At present, using available USDA statistics, only very broad assessments of change can be made and general land uses affecting the quality of the environment identified. These data can prove to be useful for designating geographical area where more intensive data collection and study are required.

2.2 Forestry

The Forest Service collects land use data with particular reference to forest land.^{1/} These data are used for productivity estimates, timber resource management, policy and legislative purposes at both state and Federal levels of government. The nationwide survey is required by the McSweeney-McNary Forest Research Act of 1928. This is a continuing survey with resurveys of states taking place at 8-15 year intervals. The survey covers 775 million acres or about one-third of the total U.S. land area. Field surveys for all 50 states were completed in 1963. The survey is conducted through the regional Forest Experiment Stations under the national direction of the Forest Survey Branch of the Division of Forest Economics and Marketing Research. Each station uses its own handbooks of procedures though they are subject to the framework established in the National Forest Survey Manual. The forest survey relies on multistage sampling techniques which combine photointerpretation, ground sampling, and automated data processing techniques. These surveys provide areal data including productivity ratings, mortality and disease estimates, and ownership information.

^{1/} Forest Land is defined by the Forest Service as "land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for non-forest use... Includes chaparral areas in the West and afforested areas. The minimum area for classification of forest land is one acre. Road-side, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, and clearing in forest areas are classed as forest if less than 120 feet in width.

Forestry data provide a good illustration of some of the problems which make existing data difficult to use for indicating environmental quality. Even though the Forest Service collects numerous kinds of data which might be useful for indicating environmental quality, historical data have been presented in such a way as to make them extremely difficult to use. Changes in the boundaries of regions, in definitions, and in data formats make comparisons from one decade to the next tedious. The Forest Service does an excellent job in footnoting and annotating its data, and could undoubtedly reconstruct former tables from raw data and estimates to meet existing data formats. Such an effort would probably provide very little additional environmental information however, and is not recommended. The absence of consistent historical data is a serious problem in developing indicators. There is a further discussion of forestry data collection procedures in Section 3.1 and in Appendix II.

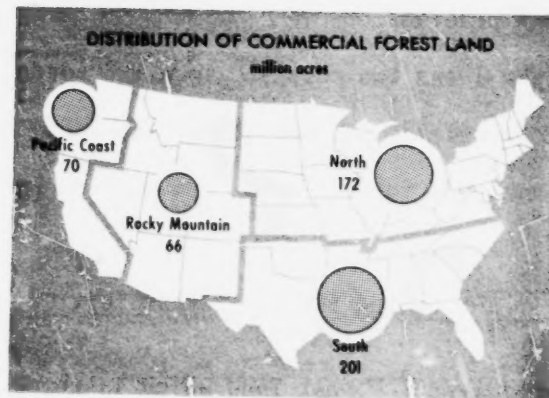
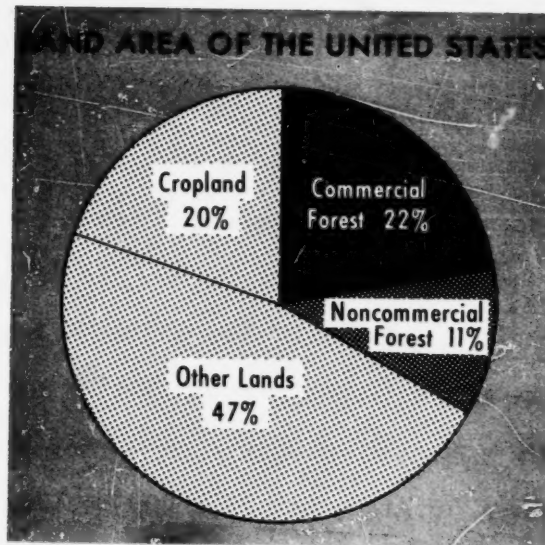
The following tables illustrate some of the potentials of forestry data and some of the problems.

Figure 2.2.0 --- These two charts^{2/} show the percentage of the total land in forests, commercial^{3/} and non-commercial, and the regional distribution of commercial forest land. The data on which these charts

^{2/} Timber Trends in the United States, Forest Service, U.S. Department of Agriculture, 1965.

^{3/} Commercial Forest Land. Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Includes areas suitable for management to grow crops of industrial wood generally capable of producing in excess of 25 cubic feet per acre of annual growth. Includes both accessible and inaccessible areas.

Figure 2.2.0



are based could, if collected over time, provide a very gross assessment of national timber resources and the rates at which those resources are being depleted or restocked. Table 2.2.0 presents data on such changes between 1953 and 1963.

An important question with respect to forest productivity is the quality of the trees growing in particular forests. The quality of forests in some states has been measured. Table 2.2.1 gives such data for 4 states.

Table 2.2.0 Changes in commercial forest land by region 1953-1963

Region	Area Jan. 1, 1963	Change Jan. 1, 1953-Jan. 1, 1963	
	Thou- sand acres	Thou- sand acres	Per- cent
New England.....	31,451	+425	+1.4
Middle Atlantic.....	43,888	+1,663	+3.9
Lake States.....	52,392	-49	-0.1
Central.....	44,058	-952	-2.2
Total North.....	171,789	+1,087	+0.6
South Atlantic.....	47,604	+1,452	+3.1
East Gulf.....	44,772	-716	-1.6
Central Gulf.....	53,361	+3,864	+7.2
West Gulf.....	55,332	+2,113	+3.8
Total South.....	201,069	+6,713	+3.3
Pacific Northwest.....	51,884	-325	-0.6
Pacific Southwest.....	18,480	-	-
Northern Rocky Mountain.....	39,287	+45	+0.1
Southern Rocky Mountain.....	26,336	+65	+0.2
Total West.....	135,987	-215	-0.2
All regions.....	508,845	+7,585	+1.5

Source: Timber Trends in the United States, Forest Service, USDA, 1966

Table 2.2.1 Percent of commercial forest land 70% or better stocked with all trees, growing stock trees, and desirable trees^{4/}

State	70 percent or better stocked with all trees	70 percent or better stocked with growing-stock trees	70 percent or better stocked with desirable growing-stock trees
Alabama.....	77	49	7
Georgia.....	70	55	7
Illinois.....	86	51	4
Tennessee.....	69	32	1

Measures of the kind, quality, or state of forests can be an important element of a land use indicator of environmental quality. Table 2.2.2 is another illustration of forest "class," assessments.

Table 2.2.2 Percent of commercial forest land in selected states by area-condition class. January 1, 1963^{5/}

States	Condition class				
	1	2	3	4	5
Alabama.....	7	12	17	4	60
Florida.....	9	4	32	1	54
Georgia.....	7	6	22	1	64
Illinois.....	4	3	28	27	38
Tennessee.....	1	4	9	5	81

^{4/} Timber Trees in the United States, Forest Service, U. S. Department of Agriculture, 1963. (Definitions for classes are not included because this table is used only to illustrate the kinds of data available.)

^{5/} Ibid.

Class 1. Areas 70 percent or more stocked with "desirable" trees. Most stands in this category do not require any special treatment to insure a high level of growth, although some stands, particularly in the West, require thinning to maintain high growth rates. (continued)

In the few States where condition class data are available, only a small proportion of the total forest area falls in the top two condition classes (Table 2.2.2). Thus in Georgia, only 7 percent of the commercial forest area was in Class 1 and 6 percent in Class 2.

On a nationwide or state-wide basis, such class data can provide a useful indicator of environmental quality.

Table 2.2.3 provides regional information on changes in timber volume. This information could be used as in Table 2.2.4 to provide volume per acre data. Historical decreases in volume per acre might indicate poor management, high mortality, or conversion of forests to other uses such as partial clearing for housing. The regional patterns of such changes can provide valuable information on the quality of the environment.

5/ "Continued"

- Class 2. Areas 40 to 70 percent stocked with desirable trees and having favorable conditions for improved stocking. Here again no special treatment is ordinarily required.
- Class 3. Areas 40 to 70 percent stocked with desirable trees and with more than 30 percent of the area controlled by other trees, inhibiting vegetation, and/or surface conditions that prevent occupancy by desirable trees.
- Class 4. Areas less than 40 percent stocked with desirable trees but expected to restock naturally.
- Class 5. Areas less than 40 percent stocked with desirable trees and requiring planting and/or stand conversion to improve stocking.

Table 2.2.3 Change in growing stock and sawtimber inventories on commercial forest land by section and by softwoods and hardwoods 1/1/53 - 1/1/63 6/

GROWING STOCK

Section	All species		Softwoods		Hardwoods	
	Million cu. ft.	Percent	Million cu. ft.	Percent	Million cu. ft.	Percent
North.....	+24,418	+22	+4,653	+17	+19,765	+23
South.....	+14,291	+12	+10,124	+19	+4,167	+6
Rocky Mountains.....	+3,819	+4	+3,368	+4	+451	+9
Pacific coast.....	-10,489	-4	-12,493	-5	+2,004	+20
United States.....	+32,039	+5	+5,652	+1	+26,387	+16

SAWTIMBER

Section	All species		Softwoods		Hardwoods	
	Million bd. ft.	Percent	Million bd. ft.	Percent	Million bd. ft.	Percent
North.....	+45,216	+17	+5,031	+8	+40,185	+20
South.....	+37,955	+10	+36,845	+20	+1,110	+1
Rocky Mountains.....	+3,335	+1	+1,941	-	+1,394	+17
Pacific coast.....	-110,614	-7	-118,224	-8	+7,610	+24
United States.....	-24,108	-1	-74,407	-3	+50,299	+12

Table 2.2.4 Growing stock and sawtimber per acre by Section 1963 7/

Section:	Growing stock per acre (cubic feet)	Sawtimber per acre (board feet)
North.....	790	1,300
South.....	670	2,050
Rocky Mountains.....	1,500	6,380
Pacific coast.....	3,680	19,850
United States.....	1,230	4,990

6/ Ibid

7/ Ibid

Annual growth estimates (Table 2.2.5) provide additional data on the management and vigor of forest lands.

Table 2.2.5 Net annual growth per acre in 1962 by Section^{8/}

Section:	Cubic feet	Board feet
North.....	23	78
South.....	37	128
Rocky Mountains.....	14	64
Pacific coast.....	43	132
U.S. average.....	32	108

Historical mortality estimates can provide gross assessments of the destruction of timber. Changing rates can be interpreted as changes in the effectiveness of fire prevention or pesticide programs, or the emergence of new destructive agents. Nationwide data (Table 2.2.6) shows broad trends. For example: there has been a dramatic decrease in the amount of timber lost to forest fires in the last 30 years and this is largely attributed to fire prevention and control programs. Gypsy Moth infestations in the Northeast the past two years have raised concern and conflicting testimony over the long range impact, in terms of mortality rates, of this insect and over the possible spread to other regions. Timely data are required to assess the damage being done.

Table 2.2.6^{9/} Mortality estimates for 1962 by cause

Cause:	Growing stock		Sawtimber	
	(Billion cu. ft.)	(Per- cent)	(Billion bd. ft.)	(Per- cent)
Fire.....	0.3	6	1.3	7
Insects.....	1.2	21	5.4	27
Disease.....	1.2	21	3.8	19
Weather and other.....	1.3	32	5.7	29
Unknown.....	1.1	20	3.5	18
All causes.....	5.6	100	19.7	100

^{8/} Ibid

^{9/} Ibid

The final broad class of forest land use data concerns ownership.

Table 2.2.7^{10/}

Commercial forest land in the United States,
by type of ownership and section, Jan. 1, 1963.

Type of ownership	Total U.S.		North	South	Rocky Mountains	Pacific coast
	Area	Proportion				
	<i>Thousand acres</i>	<i>Percent</i>	<i>Thousand acres</i>	<i>Thousand acres</i>	<i>Thousand acres</i>	<i>Thousand acres</i>
Federal:						
National forest.....	96,804	19	10,265	10,476	43,398	32,665
Bureau of Land Management.....	5,426	1	81	27	2,076	3,242
Bureau of Indian Affairs.....	6,461	1	1,198	251	2,816	2,196
Other Federal.....	4,485	1	964	3,308	31	182
Total Federal.....	113,176	22	12,508	14,062	48,321	38,285
State.....	20,844	4	12,751	2,164	2,340	3,589
County and municipal.....	7,848	2	6,748	656	83	361
Forest industry:						
Pulp and paper.....	35,022	7	10,797	21,614	-----	2,611
Lumber.....	26,113	5	2,996	12,551	2,535	8,031
Other.....	5,493	1	523	3,257	-----	1,713
Total industry.....	66,628	13	14,316	37,422	2,535	12,355
Farm.....	151,017	30	55,503	78,897	8,769	7,848
Miscellaneous private.....	149,382	29	69,963	67,868	3,575	7,926
All ownerships.....	508,845	100	171,789	201,069	65,623	70,364

These kinds of data collected over time can provide useful information for assessing environmental quality. For example: The rate by which the amount of public forest in a region, state or county is changing can be used to determine the recreational potential of an area in terms of the per capita acreage.

^{10/} Ibid

2.3 Surface Mining and Surface Mine Reclamation

Data on surface mining and surface mine reclamation have not been collected on any systematic or regular basis by the Federal Government. A national survey of surface mining and its effects on the environment was completed in 1965 by the Bureau of Mines with the cooperation of a dozen or so agencies and committees.^{1/} It is the only source of nationwide data relating to surface mining and reclamation.

Field appraisal teams (multidisciplinary groups of scientists) made observations of surface mining and reclamation. Representative sample areas were chosen as a cross section of the surface mining activities being practiced throughout the nation. "Many varieties of terrain, climate, mining method, commodity, economic and social conditions, and other environmental factors"^{2/} were observed.

In order to establish a statistical sample, six hundred and ninety-three (693) surface mining sites were checked and information on the former use of the mined land, the present condition of the mined site, the offsite effects caused by the surface mining operation, and the uses of adjoining land was gathered.

Questionnaires were also used to gather data from states and individual surface mine operators. State data requested included:

- ^{1/} The following organizations were represented on that committee: Bureau of Mines, Office of Saline Water, Federal Water Pollution Control Administration, Geological Survey, Bureau of Indian Affairs, Bureau of Land Management, Bureau of Sport Fisheries and Wildlife, Bureau of Outdoor Recreation, the Corps of Engineers, the Soil Conservation and Forest Services, the Public Health Service, the Bureau of Public Roads, the Appalachian Regional Commission, and the Tennessee Valley Authority.
- ^{2/} Surface Mining and Our Environment; A Special Report to the Nation; U.S. Department of the Interior.

"total acreage of surface-mined land unreclaimed and partially reclaimed as of January 1, 1965, by county, and classified as to ownership of surface rights and mined rights by commodity or commodity group; acreage of completely reclaimed land, separated by source of reclamation funds; acreage of partially reclaimed land, also classified by source of reclamation funds; and acreage of completely and partially reclaimed land that we restored by nature or unknown sources."

The Soil Conservation Service estimated the acres disturbed by surface mining at the county level by commodity wherever state data were inadequate.

Mine operators were sent questionnaires requesting information on the amount of land disturbed during 1964, the ownership of the land, the number of acres reclaimed, the amount of ore produced, and the contract cost of reclamation.

Data were also gathered on the effects of surface mining on fish and wildlife habitats and the extent and location of such habitats, including stream mileage and impoundments affected by acid and sedimentation.

In addition to the 693 surface mining operations checked for establishing a statistical sample, 130 other surface mines were checked. The types of commodity being mined at these sites included bentonite, clay, coal, copper, diatomite, gold, iron, lignite, manganese, molybdenum, perlite, phosphate, sand and gravel, stone and uranium.

Most of the data provided by the study are areal, and areal data are not always sufficient to indicate the impact of surface mining on the environment.

For example, an area which has been surface mined and has not been reclaimed following the cessation of mining activities is certainly subject to increased erosion potential because of the lack of a protective vegetative cover. The larger the areal extent of the surface mining activity, the greater the possibility of increased erosion and corresponding stream sedimentation. Depending upon the commodity being mined and the effects of weathering on that particular substance, a potential exists for the production of toxic materials which, through surface or ground water runoff, can find their way to streams thereby adversely affecting the environment. While the degree of erosion, sedimentation and acid pollution would have to be determined by first-hand observation, knowledge of the number of acres disturbed by surface mining activities would, in and of itself, provide useful information on environmental quality. Because of personal values, many consider the scarring of the landscape to be aesthetically displeasing and environmentally degrading. The fact that vegetative cover must be completely destroyed to allow access to the mineral below emphasizes the point that areal statistics relating to surface mining in a given area can be useful as indicators of environmental quality.

The following is an analysis of the statistical data available on surface mining, and the utility of these data as indicators of environmental quality.

Table 2.3.0 lists by state, land disturbed by strip and surface mining in the United States as of January 1, 1965, by commodity and state, in acres. The data are limited in their value as indicators of environmental quality. The table will assist, however, in ordering priorities by identifying those states where surface mining is most

TABLE 2.3.0 -- LAND DISTURBED BY STRIP AND SURFACE MINING IN THE UNITED STATES
AS OF JANUARY 1, 1965, BY COMMODITY AND STATE [ACRES]

State	Clay	Coal (bituminous, lignite and anthracite)	Stone	Sand and gravel	Gold	Phosphate rock	Iron ore	All other	Total
Alabama ¹	4,000	50,600	3,900	21,200	100		52,600	1,500	133,900
Alaska ²		500		2,000	8,600				11,100
Arizona ¹	2,700		1,000	7,200	1,200			20,300	32,400
Arkansas ²	600	10,100	900	2,600			100	8,100	22,400
California ²	2,700	20	8,000	19,900	134,000		900	8,500	174,020
Colorado ¹	2,000	2,800	6,200	15,500	17,100		25	11,400	55,025
Connecticut ¹			100	16,100				100	16,300
Delaware ²	200		200	5,200			100	10	5,710
Florida ¹	13,200		25,300	3,900		143,600		2,800	188,800
Georgia ²	*1,300	*300	*6,800	*1,200			*100	*12,000	*21,700
Hawaii ²								10	10
Idaho ²	500		700	11,200	21,200	3,100	35	4,200	40,935
Illinois ²	1,400	127,000	5,700	9,000					143,100
Indiana ²	1,500	95,200	10,200	18,000				400	125,300
Iowa ¹	1,300	11,000	12,200	17,600			6	2,300	44,406
Kansas ²	*1,100	*45,600	*7,500	*5,100				*200	59,500
Kentucky ²	*2,400	*119,200	*3,900	*1,700					127,700
Louisiana ¹	900		100	29,700			50		30,750
Maine ¹	400		4,400	28,200	12		100	1,700	34,812
Maryland ²	*1,200	*2,200	*2,200	*18,800			*20	*800	25,220
Massachusetts ¹	700		1,200	36,400			1,100	900	40,300
Michigan ²	600		7,700	25,200			2,200	1,200	36,900
Minnesota ¹	600		3,900	41,600	3		67,700	1,600	115,403
Mississippi ²	2,700		400	26,500			30		29,630
Missouri ²	6,600	31,200	8,400	3,800			200	8,300	59,100
Montana ²		1,500	10	*13,500	5,600	100	10	6,200	26,920
Nebraska ²	900		4,300	23,700					28,900
Nevada ¹	100		1,600	5,500	5,600		600	19,500	32,900
New Hampshire ²			100	8,000				200	8,300
New Jersey ²	1,400		2,000	27,600			1,000	1,800	33,800
New Mexico ²	13	1,200	100	400	40		100	4,600	6,453
New York ¹	1,700		12,500	42,200	5		700	600	57,705
North Carolina ¹	5,800	10	6,000	18,400	2,200	300	100	4,000	36,810
North Dakota ²	*800	*7,700	*300	*26,100				*2,000	36,900
Ohio ²	*10,200	*212,800	*21,000	*28,100			*4,000	*600	276,700
Oklahoma ²		23,500		*2,500				1,400	27,400
Oregon ²	100		300	1,300	6,300		10	1,400	9,410
Pennsylvania ²	*10,400	*302,400	*24,400	*23,800	*2		*8,800	*400	370,202
Rhode Island ¹			20	3,600					3,620
South Carolina ¹	10,900		1,400	10,400	200	8,100	100	1,600	32,700
South Dakota ²	*2,000	*900		*28,000				*3,300	34,200
Tennessee ²	2,700	29,300	4,400	18,400		27,000	5,300	13,800	100,900
Texas ¹	6,800	2,900	21,900	122,300			9,600	2,800	166,300
Utah ²	600		200	2,200		10	500	2,000	5,510
Vermont ²			*2,300	*4,000				*400	6,700
Virginia ²	*1,100	*29,800	*4,300	*13,100	*600	*100	*7,700	*4,100	60,800
Washington ²	500	100	1,300	5,700	400		20	800	8,820
West Virginia ²	300	192,000	2,800	300			100		195,500
Wisconsin ²	100		9,000	26,400	5		49		35,554
Wyoming ²	*3,500	*1,000	*300	*200		*800	*300	*4,300	10,400
Total	108,513	1,301,430	241,430	823,300	203,167	183,110	164,255	162,620	3,187,825

* Estimate.

¹ Data obtained from Soil Conservation Service, U. S. Department of Agriculture.

² Data compiled from reports submitted by the States on U. S. Department of the Interior form 6-1385X.

Source: Surface Mining and Our Environment: A Special Report to the Nation;
U. S. Dept. of the Interior.

disruptive by type and area and where corrective action should first be applied.

Table 2.3.1 lists the status of land distributed by strip and surface mining in 1965. The "land requiring reclamation" column lists data which are very useful as indicators of environmental quality, and gives a fairly accurate picture of the number of acres of land per state which in some way are environmentally-degraded. If these types of data were collected at regular intervals with consistent methods of collection, the progress of reclamation would be known. These data do not, however, identify the effects of unreclaimed land, areally or otherwise, on the surrounding area; and they provide no information on the time it may take to restore the ecological balance of adjacent areas once the mined area has been reclaimed or otherwise converted to some other (e.g., recreational) useful state. Nevertheless, these data are among the more useful encountered in this study.

Table 2.3.2 gives the number of public and private acres disturbed by clay, coal, stone, and sand and gravel mining in nine regional areas. Although surface mining effects such as acid and sediment pollution cross jurisdictional boundaries thereby creating a regional problem, the primary responsibility for eliminating the damaging effects of mining rests with the individual surface mine operator. The states are responsible for ensuring that the individual mine operators comply with the laws. Therefore, while data on the areal extent of disturbed private and public surface mined lands by region and commodity provides a picture of regional environmental deterioration, it neither adds to nor enhances the areal data described in Tables 2.3.0 and 2.3.1 in terms of its usefulness as indicators of environmental quality.

TABLE 2.3.1 -- Status of Land Disturbed by Strip and Surface Mining
in the United States as of January 1, 1965, by State
(Thousand Acres)

State	Land requiring reclamation ¹	Land not requiring reclamation ¹	Total land disturbed ²	State	Land requiring reclamation ¹	Land not requiring reclamation ¹	Total land disturbed ²
Alabama	83.0	50.9	133.9	Nebraska	16.8	12.1	28.9
Alaska	6.9	4.2	11.1	Nevada	20.4	12.5	32.9
Arizona	4.7	27.7	32.4	New Hampshire	5.1	3.2	8.3
Arkansas	16.6	5.8	22.4	New Jersey	21.0	12.8	33.8
California	107.9	66.1	174.0	New Mexico	2.0	4.5	6.5
Colorado	40.2	14.8	55.0	New York	50.2	7.5	57.7
Connecticut	10.1	6.2	16.3	North Carolina	22.8	14.0	36.8
Delaware	3.5	2.2	5.7	North Dakota	22.9	14.0	36.9
Florida	143.5	45.3	188.8	Ohio	171.6	105.1	276.7
Georgia	13.5	8.2	21.7	Oklahoma	22.2	5.2	27.4
Hawaii	(3)	(3)	(3)	Oregon	5.8	3.6	9.4
Idaho	30.7	10.3	41.0	Pennsylvania	229.5	140.7	370.2
Illinois	88.7	54.4	143.1	Rhode Island	2.2	1.4	3.6
Indiana	27.6	97.7	125.3	South Carolina	19.3	13.4	32.7
Iowa	35.5	8.9	44.4	South Dakota	25.3	8.9	34.2
Kansas	50.0	9.5	59.5	Tennessee	52.5	38.4	100.9
Kentucky	79.2	48.5	127.7	Texas	136.4	29.9	166.3
Louisiana	17.2	13.6	30.8	Utah	3.4	2.1	5.5
Maine	21.6	13.2	34.8	Vermont	4.2	2.5	6.7
Maryland	18.1	7.1	25.2	Virginia	37.7	23.1	60.8
Massachusetts	25.0	15.3	40.3	Washington	5.5	3.3	8.8
Michigan	26.6	10.3	36.9	West Virginia	111.4	84.1	195.5
Minnesota	71.5	43.9	115.4	Wisconsin	27.4	8.2	35.6
Mississippi	23.7	5.9	29.6	Wyoming	6.4	4.0	10.4
Missouri	43.7	15.4	59.1				
Montana	19.6	7.3	26.9	Total	2,040.6	1,147.2	3,187.8

¹ Compiled from data supplied by Soil Conservation Service, U. S. Department of Agriculture.

² Data compiled from reports submitted by the States on U. S. Department of the Interior form 6-1385X, from Soil Conservation Service, U. S. Department of Agriculture, and estimates.

³ Less than 100 acres.

Source: Surface Mining and Our Environment; A Special Report to the Nation;
U.S. Department of the Interior

34c

TABLE 2.3.2 -- Land Disturbed and Production at Strip and Surface Mines in the United States in 1964 for Selected Commodities, by Ownership and Geographic Areas^{1/}

Geographic area	Clay						Coal					
	Acres disturbed				Production		Acres disturbed				Production	
	Private	Per-cent	Public	Per-cent	Thousand short tons	Per-cent ²	Private	Per-cent	Public	Per-cent	Thousand short tons	Per-cent ²
New England	37	100.0	.....	.....	290	64.0	.....	.....	.....	.....	.....	.....
Middle Atlantic	386	99.5	2	0.5	2,136	41.1	5,246	94.0	334	6.0	15,365	45.3
South Atlantic	672	95.6	3	.4	8,413	56.8	3,888	95.7	173	4.3	7,992	38.9
East North Central	304	98.4	5	1.6	5,704	51.6	14,674	95.9	629	4.1	58,782	86.2
East South Central	238	99.2	2	.8	1,384	37.8	4,004	96.9	126	3.1	25,603	72.6
West North Central	458	99.8	1	.2	2,152	49.8	1,896	96.9	2	.1	4,913	92.9
West South Central	1,749	98.8	21	1.2	4,753	71.3	469	71.3	189	28.7	3,202	92.9
Mountain	487	64.2	272	35.8	1,873	84.1	534	91.0	53	9.0	6,352	93.9
Pacific	460	98.3	8	1.7	1,557	34.9	10	25.0	30	75.0	528	68.6
Total	4,791	93.8	314	6.2	28,262	53.4	30,721	95.2	1,536	4.8	122,737	70.3
Geographic area	Stone						Sand and gravel					
	Acres disturbed				Production		Acres disturbed				Production	
	Private	Per-cent	Public	Per-cent	Thousand short tons	Per-cent ²	Private	Per-cent	Public	Per-cent	Thousand short tons	Per-cent ²
New England	51	100.0	.....	.....	7,148	43.3	462	94.3	28	5.7	13,102	22.9
Middle Atlantic	556	99.3	4	0.7	46,721	49.5	692	98.4	11	1.6	23,910	32.7
South Atlantic	1,271	93.3	91	6.7	27,644	18.7	1,756	95.7	78	4.3	19,465	29.7
East North Central	954	98.1	18	1.9	69,380	45.8	3,035	94.7	170	5.3	104,792	57.2
East South Central	344	84.3	64	15.7	6,763	13.3	342	87.2	50	12.8	6,554	29.3
West North Central	1,588	98.3	27	1.7	51,915	65.7	4,218	93.3	305	6.7	36,290	32.1
West South Central	1,420	100.0	.....	.....	33,143	40.0	4,593	93.3	329	6.7	25,865	42.2
Mountain	319	67.4	154	32.6	9,060	37.4	2,519	72.3	967	27.7	42,813	41.5
Pacific	414	77.2	122	22.8	8,243	10.4	1,182	36.7	2,036	63.3	57,313	30.2
Total	6,917	93.5	480	6.5	260,017	35.8	18,799	82.5	3,974	17.5	330,104	38.0

¹ As reported voluntarily by producers on U. S. Department of the Interior forms 6-1386X and 6-1387X.

² Percent of production reported and published in the U. S. Bureau of Mines Minerals Yearbook, 1964.

NOTE: Phosphate rock; land reported disturbed in 1964 totaled 2,450 acres, only 20 acres of which was publicly owned. Production reported, 20,740,000 net tons, or 28 percent of the United States total. Of total land disturbed, 81 percent was in the South Atlantic States; 15 percent in the East South Central States; and, 4 percent in the Mountain States.

Source: Surface Mining and Our Environment; A Special Report to the Nation;
U.S. Department of the Interior

Table 2.3.3 shows fish and wildlife habitats adversely affected by strip and surface mining. These data, if they were collected at regular intervals, would establish the degree of success of surface mine reclamation efforts on a statewide and national basis. The revitalization of a given water body formerly polluted by acid drainage and devoid of life, is a good indication that not only surface revegetation and regrading have been successful, but also that toxic materials have been properly covered. For this reason, data on the number of miles of streams and the surface acres of natural lakes, reservoirs, and impoundments adversely affected by strip and surface mining, if collected on a regular basis, would be better indicators of environmental recovery than data covering only the number of acres reclaimed over a given time period. In effect, data collected over time on the number of acres reclaimed are only a partial indicator of environmental recovery. Regrading and revegetation have eliminated the onsite environmental degradation almost immediately, but the off-site effects will continue for a longer period of time.

No statistical data were found presenting the degree of success of on-site reclamation efforts. In some cases a disturbed area is regraded and revegetated, but for various reasons, the vegetation does not take hold and the reclamation effort is considered unsuccessful. In the past, many surface mine operations were abandoned without ever having been reclaimed. Sometimes natural vegetative succession would take place and the area became "naturally reclaimed," but often because of the exposure of toxic materials to the processes of weathering, as well as the presence of steep slopes and high walls, environmental degradation can continue. Regularly collected data are lacking in these cases, and are needed in order to ensure an accurate inventory of on-going environmental damage.

TABLE 2.3.3 -- Fish and Wildlife Habitat Adversely Affected by Strip and Surface Mining in the United States, as of January 1, 1967, by State¹

State	Streams		Natural lakes		Reservoirs and impoundments		Wildlife habitat
	Miles	Surface acres	Number	Surface acres	Number	Surface acres	Acres
Alabama	275	1,700	---	---	7	16,300	12,000
Alaska	60	500	---	---	---	---	1,000
Arizona	30	200	---	---	---	---	30,000
Arkansas	150	700	2	200	---	---	32,400
California	320	834	3	70	1	4	61,270
Colorado	880	1,930	---	---	13	600	21,515
Connecticut	62	415	2	100	---	---	16,783
Delaware	(2)	(2)	---	---	5	200	6,000
Florida	(2)	(2)	---	---	---	---	41,000
Georgia	185	510	---	---	10	390	800
Hawaii	---	---	---	---	---	---	355
Idaho	134	654	---	---	---	---	16,460
Illinois	60	350	---	---	50	500	132,395
Indiana	90	750	---	---	---	---	108,744
Iowa	---	---	---	---	---	---	---
Kansas	100	614	---	---	2	50	38,500
Kentucky	395	7,000	---	---	---	---	66,700
Louisiana	1,714	42,500	250	100,000	---	---	3,000
Maine	4	5	---	---	---	---	33,274
Maryland	115	500	---	---	1	72	7,500
Massachusetts	6	600	---	---	---	---	50
Michigan	253	506	16	1,560	32	900	30,729
Minnesota	---	---	6	1,600	---	---	(2)
Mississippi	30	190	---	---	1	300	1,900
Missouri	330	2,550	---	---	2	6,000	29,500
Montana	136	234	---	---	---	---	10,830
Nebraska	700	21,600	---	---	---	---	16,915
Nevada	41	31	---	---	---	---	(2)
New Hampshire	35	1,500	---	---	---	---	1,000
New Jersey	10	90	---	---	---	---	(2)
New Mexico	100	1,150	---	---	1	2	47,540
New York	24	100	2	100	---	---	26,350
North Carolina	---	---	---	---	---	---	850
North Dakota	---	---	---	---	---	---	33,140
Ohio	1,200	1,200	---	---	1	120	67,920
Oklahoma	20	73	---	---	---	---	28,306
Oregon	310	620	---	---	---	---	13,666
Pennsylvania	3,000	9,100	---	---	4	2,020	392,000
Rhode Island	2	1	---	---	---	---	310
South Carolina	---	---	---	---	---	---	800
South Dakota	640	3,250	---	---	33	9,275	23,000
Tennessee	350	3,983	---	---	1	100	20,000
Texas	---	---	---	---	---	---	146,087
Utah	16	90	---	---	---	---	11,434
Vermont	32	70	---	---	---	---	(2)
Virginia	260	1,015	---	---	---	---	6,000
Washington	64	640	---	---	---	---	---
West Virginia	755	28,015	---	---	4	4,683	149,185
Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)	---
Wyoming	10	200	---	---	---	---	NA
Total	12,898	135,970	281	103,630	168	41,516	1,687,288

NA — Not available.

¹ Compiled from data obtained from State fish and game personnel.

² Insignificant.

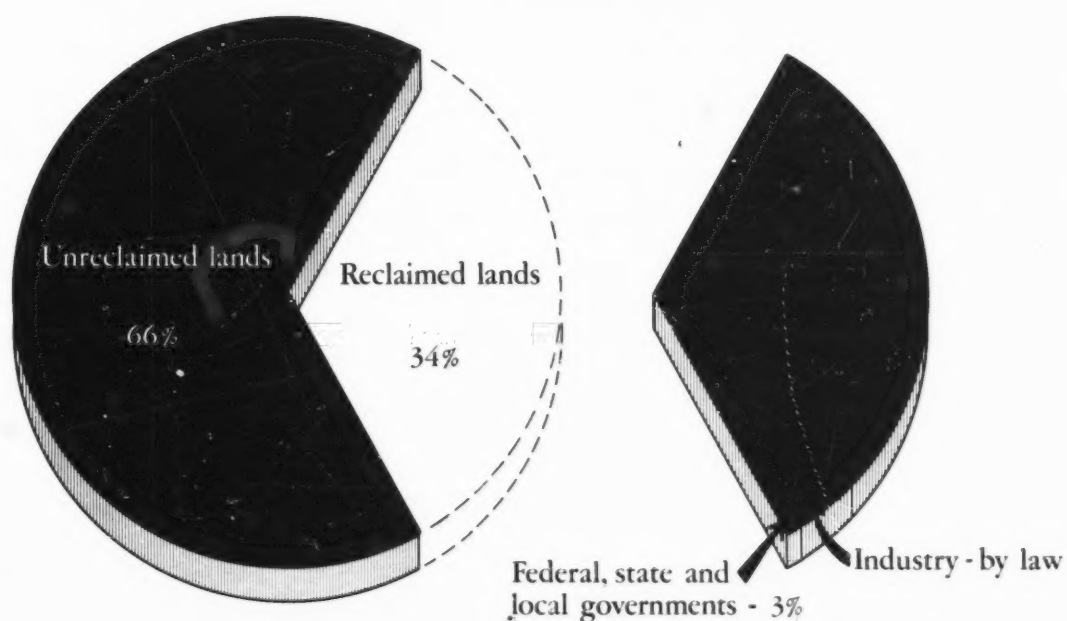
Source: Surface Mining and Our Environment; A Special Report to the Nation; U.S. Department of the Interior.

Chart I shows that only 34% of the total amount of disturbed land in the nation has been reclaimed. Of the reclaimed land, 46% has been by "natural reclamation," while 40% has been reclaimed voluntarily by industry, 11% by law by industry and only 3% by Federal, state and local governments. As previously mentioned, "natural reclamation" is not the best way of reclaiming a surface mined area. Because of new and increasing numbers of reclamation laws requiring the individual mine operator to post a bond, which is held by the state until the operator has successfully reclaimed the area disturbed by his mining operation, the "industry by law" category on the chart should grow with a corresponding decrease in the "nature" category. Land use data contained in this chart is, therefore, useful as a broad indicator of environmental quality if it is updated regularly under the assumption that lands reclaimed by laws requiring strict environmental standards will have more of a utilitarian value and be more environmentally enhancing than "naturally reclaimed" lands.

Chart II, a map bar chart showing total acreage disturbed by surface mining as of January 1, 1965, pictorially represents those areas in the United States having the largest quantity of disturbed surface mined lands and those areas which are relatively unaffected by surface mine disturbance. There is an obvious concentration of disturbed lands in the eastern part of the country, particularly in the Appalachian coal-producing states. Data used in the compilation of this chart are listed in Table 1, but in tabular form the data do not project important spatial relationships. These relationships could be easily overlooked if it were not for their presentation through mapping. Updated map presentations of areal statistical data, can prove an important and useful technique for showing areal and spatial relationships that are direct indicators of environmental quality.

CHART I

*Status of Land Disturbed by Surface Mining
as of January 1, 1965*



Source: Surface Mining and Our Environment; A Special Report to the Nation;
U.S. Department of the Interior

CHART II

Total Acreage Disturbed by Surface Mining as of January 1, 1965

Source: Surface Mining and Our Environment; A Special Report to the Nation;
U.S. Department of the Interior

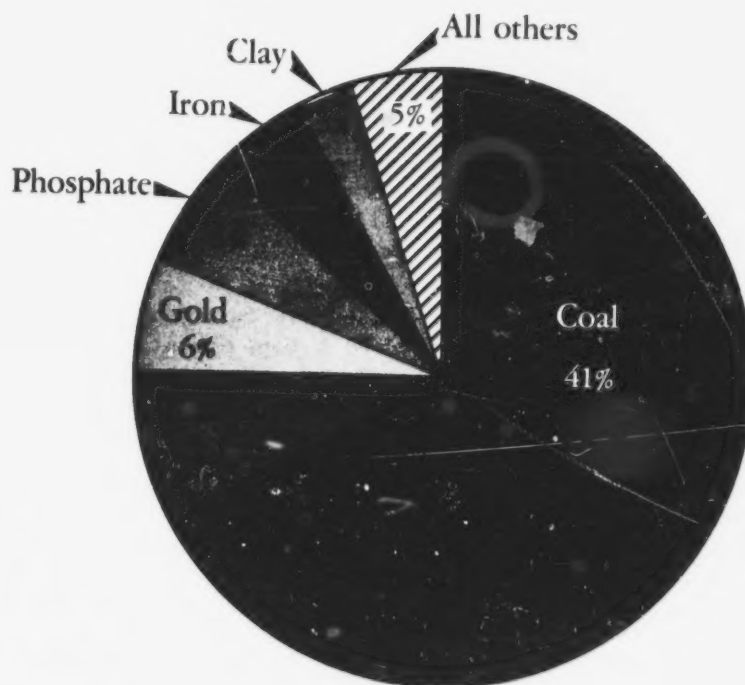
If Chart III were updated at regular intervals we would obtain a very useful picture showing areal changes (the increase or decrease in land disturbed by surface mining by commodity) directly related to environmental quality.

Chart IV shows area disturbed by coal stripping (in thousand acres) for the nation over a five year period. Between 1965 and 1969, there was a gradual linear increase in the total number of acres disturbed by surface mining. In 1969, there was a sharp change in the rate at which lands were being disturbed and in one year (1969-70) approximately the same amount of land was disturbed (25,000 acres) as was disturbed for the entire period between 1965 and 1969. Land use data presented in such a format are useful for showing quantities and rates of change over time and are helpful for identifying intensities of environmental degradation or recovery and for predicting future trends.

Most of the data described above are useful as indicators of environmental quality only if collected over time and presented in a consistent format. Further efforts will have to be directed toward the timely and orderly collection of relevant data. The Bureau of Mines has developed a Mining Industry Land Utilization Questionnaire which requests operators of surface mines to provide data which will permit a more comprehensive and periodic assessment of the use of land by the mining industry. Data requested includes: (1) surface area mined in acres; (2) mined surface area upon which reclamation work was completed; (3) surface area utilized for disposal of mine wastes; and (4) surface area of mine waste accumulations reclaimed. Data are requested for the surface mining operation during the previous calendar year. Depending upon the outcome of the current test program, data may also be requested for all years prior to the previous

CHART III

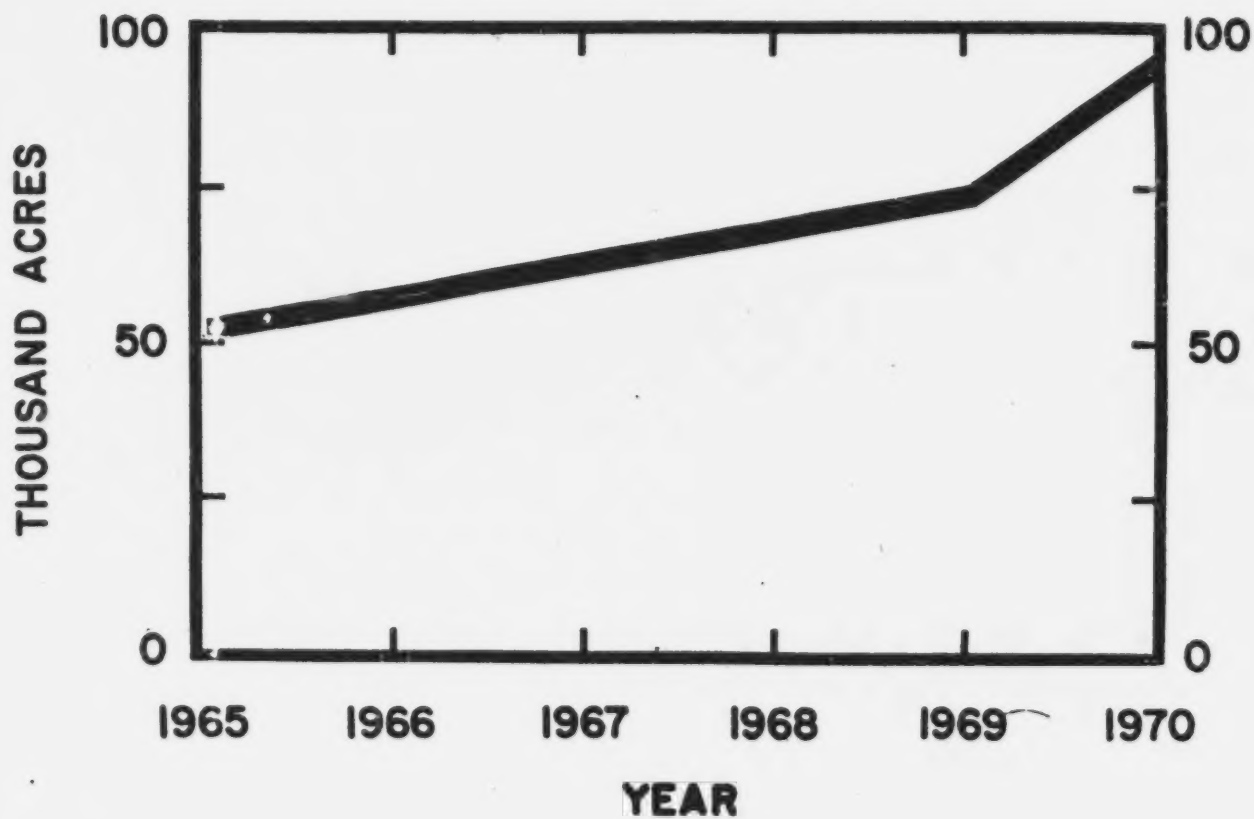
*Percentage of Land Disturbed by Surface Mining
of Various Commodities as of January 1, 1965*



Total: 9.2 million acres.

Source: Surface Mining and Our Environment; A Special Report to the Nation;
U.S. Department of Interior

CHART IV

AREA DISTURBED BY COAL STRIPPING

Source: U.S. Bureau of Mines

calendar year. All Bureau of Mines questionnaires are treated confidentially and information supplied by the mine operators is strictly on a voluntary basis.^{1/}

If the response to this questionnaire is favorable, data useful as indicators of environmental quality will soon be available. The data will be updated yearly and the environmental deterioration or recovery of an area could be followed.

^{1/} The questionnaire also requests data on underground mining activities as well as milling operations.

2.4 Public Works

The principal public works affecting land use are the building of highways and the development of water resources. Transportation is discussed in Section 2.7. Section 2.4 will, therefore, be limited to data collected by the Federal Government which deals with water resource development and land use. Appendix III contains and describes in more detail the data available on land use and water resources from the principal Federal agencies with water resource development activities.

The Civil Works Program of the Army Corps of Engineers is responsible for more than one-third of the direct expenditures of the Federal Government for public works.^{1/} As a result of its programs the Corps gathers large amounts of data on navigation, flood control, shoreline protection, and recreation. These data are summarized in 50 state reports on water resources development and associated public works projects. Unfortunately these reports do not provide very useful areal land use data. The data they contain largely describe the costs and benefits of specific projects rather than the project impact on land use and on the environment.^{2/} The Corps does collect some usage data for its recreational and water transportation projects. Since these data are for small areas of no particular geographical or political significance (canals and waterways for example), the Corps data can not be readily integrated with data from other sources. Data are collected during feasibility and preliminary engineering studies, and similar data are not likely to be collected again. The requirement to provide environmental impact statements for recent projects has redirected the Corps' focus, though this has not yet resulted in a significant accumulation of land

^{1/} Water Resources Development, U.S. Army, Office of the Chief of Engineers, Technical Liaison Office, Washington, D.C., 1969

^{2/} This has changed since the enactment of the National Environmental Policy Act of 1969.

use data. The Corps is presently considering an automated data processing system which would contain land use and other environmental data.

Table 2.4.0^{3/} illustrates the kind of annual user data collected by the Corps. Such data could prove useful as land use indicators of environmental quality. Were similar data for recreational facilities managed by other Federal, state and local agencies, as well as spatial description of the facilities available, it would be possible to analyze recreational needs within a region. Increased recreational opportunities are an important secondary benefit of water resource developments intended primarily to control floods, generate power, provide water, and improve navigation. It is apparent in many areas that this secondary benefit is placing great environmental stress on the water resources. For example, reservoirs are silting-up faster than projected because of runoff from unanticipated construction, and power boats and septic tanks are polluting waters originally impounded for human consumption. Data on land use within the basins of impounded rivers and lakes is needed to manage the reservoirs. Such data are not now available in a consistent form within the Federal Government.

The only areal data contained in Table 2.4.0 give the water surface area of the "normal recreational pool". For the contiguous states these data show that the surface area of recreational lakes developed by the Corps of Engineers is more than 4.4 million acres.

^{3/} Recreation, Corps of Engineers, Department of the Army.

STATE	MAP KEY NO.	PROJECT NAME AND RIVER LEGEND: NPP - NO PERMANENT POOL NA - NOT APPLICABLE — - DATA NOT AVAILABLE	ENGINEER DISTRICT NUMBER (See Page 44)	ATTENDANCE		WATER SURFACE ACRES IN NORMAL RECREATIONAL POOL	NORMAL RECREATIONAL POOL SHORELINE MILES	RECREATIONAL FACILITIES							NUMBER BOATS OPERATING IN PROJECT AREA	REPORTED CATCH OF SPORT FISH AT PROJECT (POUNDS)
				TOTAL ANNUAL	PEAK DAY			RESERVOIR ACCESS AREAS	BOAT LAUNCHING LANES	PICNIC AREAS	SWIMMING BEACHES	TENT & TRAILER SPACES	GUEST RENTAL UNITS	ORGANIZED CAMPS		
ALA	1	Black Warrior, Warrior, Tombigbee Res., 12 Ls/Ds (Rivers of same name)	18	1,551,700	72,988	110,383	1,600	32	27	19	0	26	0	0	240	67,900
ARK	1	Beaver Res., White R.	14	1,536,000	11,900	28,220	449	16	125	23	10	138	0	0	240	657,000
	2	Blakely Mt. Dam (Lake Ouachita) Ouachita R.	36	2,319,000	78,500	40,060	690	18	107	20	6	2,900	140	4	470	600,000
	3	Blue Mountain Res., Petit Jean R.	14	146,000	3,900	2,900	50	10	9	12	1	40	0	0	34	50,000
	4	Bull Shoals Res., White R. (Also Mo.)	14	1,992,600	18,200	48,640	740	29	184	20	20	489	39	2	924	1,089,600
	5	Dardanelle L & D., Arkansas R.	14	1,318,100	19,300	35,600	315	20	35	14	0	85	0	0	151	133,000
	6	Greers Ferry Res., Little Red R.	14	1,431,000	45,600	31,500	276	15	56	14	1	314	0	0	464	1,016,000
	7	Millwood Res., Little R.	35	151,300	2,340	24,500	65	2	4	2	1	10	0	0	0	10,000
	8	Narrows Res., (Lake Greason) L. Missouri R.	36	1,921,000	57,990	7,260	134	15	55	18	6	1,650	31	1	53	110,000
	9	Nimrod Res., Fourche La Pave R.	14	357,400	6,700	3,600	77	15	9	7	2	60	0	0	50	240,000
	10	Norfolk Res., North Fork R. (Also Mo.)	14	1,533,500	33,600	22,000	380	21	72	21	9	247	0	1	418	1,191,300
CALIF	1	Black Butte Res., Stony Creek	29	213,390	7,000	2,845	25	4	7	2	0	25	0	0	0	10,000
	2	Brea Reservoir, Brea Creek	15	337,072	1,153	NPP	NPP	4	0	0	0	0	0	0	0	—
	3	Coyote Valley Res. (Lake Mendocino) E. Fork Russian R.	30	1,094,650	48,300	1,662	14	4	10	4	2	136	0	0	30	13,000
	4	Hansen Res., Los Angeles R.	15	2,428,475	40,600	115	3	8	2	11	1	0	0	0	0	—
	5	Harry L. Englebright Debris Basin, Yuba R.	29	125,370	2,500	750	10	2	2	5	3	0	0	0	4	8,000
	6	Isabella Res., Kern R.	29	1,429,890	50,000	4,800	28	16	17	7	3	665	0	3	245	640,000
	7	New Hogan Res., Calaveras R.	29	344,210	10,000	2,650	42	3	3	1	1	25	0	0	0	12,000
	8	North Fork Debris Basin, N. Fork of American R.	29	38,600	800	280	15	1	1	2	2	0	0	0	0	8,000
	9	Pine Flat Res., Kings R.	29	589,240	10,500	3,700	53	5	8	11	4	140	0	0	60	187,500
	10	Prado Res., Santa Ana R.	15	243,575	2,915	NPP	NPP	4	0	10	0	0	0	0	0	—
	11	Sepulveda Res., Los Angeles R.	15	1,712,738	28,950	NPP	NPP	12	0	2	0	0	0	0	0	—
	12	Success Res., Tule R.	29	565,990	8,500	600	7	6	7	3	6	50	0	0	29	70,000
	13	Terminus Res., Kaweah R.	29	396,600	9,500	570	8	5	4	4	2	0	0	0	12	30,000
	14	Whittier Narrows Res., Rio Hondo & San Gabriel R.	15	1,280,557	41,500	64	2	13	0	2	0	0	0	0	0	1,000
COLO	1	Cherry Creek Res., Cherry Creek	23	480,100	14,400	852	8	2	10	5	1	105	0	0	10	4,000
	2	John Martin Res., Arkansas R.	02	237,779	7,065	NPP	NPP	2	2	4	1	36	0	1	2	40,000
CONN	1	Mansfield Hollow Res., Natchaug R.	20	147,900	1,980	477	11	16	1	2	0	0	0	0	0	22,000
	2	Northfield Brook Res., Northfield Brook	20	10,190	300	10	NA	0	0	0	0	0	0	0	0	—
	3	Thomaston Res., Naugatuck R.	20	73,060	1,500	NPP	NPP	11	0	0	0	0	0	0	0	—
	4	West Thompson Res., Quinebaug R.	20	30,440	300	200	—	0	0	0	0	0	0	0	0	—
FLA	1	Central & So. Fla., Flood Control Project	12	488,500	88,000	NA	NA	26	36	8	0	0	0	0	180	1,021,000
	2	Jim Woodruff L. & D. (Lake Seminole) Chattahoochee R., (Also Ga. & Ala.)	18	1,148,000	30,000	37,500	250	51	41	39	4	282	43	0	229	375,000
	3	Okeechobee Lake and Waterway	12	1,636,300	33,000	463,150	NA	27	33	26	3	7	0	1	—	—

TABLE 2.4.0 -- Recreational Use and Facilities - U. S. Army Corps of Engineers

The Tennessee Valley Authority has collected and assembled extensive data on land use within the TVA region, and has produced land use maps. These data are used for planning, engineering, and management and are updated periodically.

The Department of Agriculture collects water resource data through a variety of programs (Appendix III). These data provide areal information on irrigation and drainage projects, and on the area water impoundments made with USDA loans.

Tables 2.4.1 and 2.4.2 illustrate the data on irrigation which are available from the U.S. Census of Agriculture. These data are collected regularly. Table 2.4.1 provides data by state and region, while 2.4.2 provides data by river basin. Data on the amount of land under irrigation and the rates of change can be a useful element of an environmental indicator on agriculture. The data need not be spatially oriented; it should be sufficient to know land area involved in a state or region at regular intervals. These data must be combined with other agricultural land use data and with water quality data before meaningful environmental assessments can be made.

TABLE 2.4.1 -- Irrigated Land in Farms, 31 Humid-Area States, 1939-64

State and region	Irrigated land in farms					
	1939	1944	1949	1954	1959	1964
	----- Acres -----					
Maine.....	143	100	2,299	1,097	2,214	4,157
New Hampshire.....	25	63	622	942	1,249	2,648
Vermont.....	0	6	303	689	1,612	1,063
Massachusetts.....	2,049	11,355	18,507	22,683	19,999	24,178
Rhode Island.....	109	133	1,631	1,009	406	1,428
Connecticut.....	520	496	8,088	11,975	5,171	14,452
New York.....	5,948	10,316	19,248	59,024	57,997	79,193
New Jersey.....	7,956	11,712	28,117	58,912	73,873	96,433
Pennsylvania.....	3,356	8,764	7,251	17,950	16,523	22,734
Delaware.....	7	22	404	5,553	15,533	17,542
Maryland.....	67	287	697	8,344	11,174	15,996
Northeast.....	20,180	43,254	87,167	188,178	205,751	279,824
Michigan.....	2,960	2,850	13,901	23,473	40,178	48,991
Wisconsin.....	2,345	4,569	9,781	18,199	31,862	62,302
Minnesota.....	2,968	210	4,235	9,207	14,991	17,510
Lake States.....	8,273	7,629	27,917	50,879	87,031	128,803
Ohio.....	4,536	4,178	5,706	15,379	11,972	17,405
Indiana.....	685	830	5,339	11,738	17,237	16,924
Illinois.....	307	368	1,510	6,789	10,127	14,375
Iowa.....	2,258	1,197	1,386	2,396	18,181	21,528
Missouri.....	960	1,113	2,089	32,998	29,957	59,426
Corn Belt.....	8,746	7,686	16,030	69,300	87,474	129,658
Virginia.....	687	1,419	2,817	21,805	31,101	50,968
West Virginia.....	270	42	40	1,387	1,115	2,420
North Carolina.....	246	229	2,083	25,423	65,743	96,874
Kentucky.....	205	230	485	13,434	8,605	14,405
Tennessee.....	311	393	1,012	22,548	10,979	10,737
Appalachian.....	1,719	2,313	6,437	84,591	117,543	175,404
South Carolina.....	411	62	6,408	22,009	24,952	18,524
Georgia.....	158	423	3,161	23,873	33,700	64,112
Florida.....	126,191	221,917	365,421	427,807	413,526	1,217,192
Alabama.....	281	487	367	16,658	17,357	11,768
Southeast.....	127,041	222,889	375,357	490,347	489,535	1,311,596
Mississippi.....	94	3	5,086	132,490	99,686	123,398
Arkansas.....	159,412	288,665	422,107	857,863	711,812	974,279
Louisiana.....	413,969	535,619	576,775	707,818	484,850	580,687
Delta States.....	573,475	824,287	1,003,968	1,698,171	1,296,348	1,678,364
Total 31 humid-area States.....	739,434	1,108,058	1,516,876	2,581,466	2,283,682	3,703,649

Source: U.S. Census of Agriculture, 1940, 1950, 1959, and 1964.

TABLE 2.4.2 -- Comparative Estimated Rates of Change in 1964 and 1967 in Irrigated Land in Farms, United States, Based on 1939-64 Trends, by Water Resource Regions

Water resource region (See fig. 14)	1964 census year			1967 current estimate			Acreage distribution in 1967 ^{2/} (percent)
	Total acres	Annual change ^{1/}		Total acres	Annual change ^{1/}		
		Acres	Percent		Acres	Percent	
New England.....	47	2	3.45	52	2	4.00	1.2
Delaware and Hudson.....	224	23	11.17	308	31	11.17	7.4
Chesapeake Bay.....	59	5	8.47	74	5	7.24	1.8
Southeast.....	1,151	93	8.71	1,478	118	8.71	35.7
Eastern Great Lakes.....	37	2	7.09	45	3	6.50	1.1
Western Great Lakes.....	69	5	7.30	84	5	5.84	2.0
Ohio.....	57	6	11.21	78	8	11.21	1.9
Cumberland.....	2	3/	11.21	2	3/	11.21	0.1
Tennessee.....	11	1	11.21	14	1	11.21	0.3
Upper Mississippi.....	85	7	8.97	106	7	7.07	2.6
Lower Mississippi.....	681	47	7.37	843	58	7.37	20.3
Lower Missouri.....	25	2	8.69	31	2	6.89	0.8
Lower Arkansas-White-Red..	827	58	7.46	1,026	71	7.46	24.8
Eastern mainland.....	3,275	257	8.51	4,141	310	8.51	10.2
Upper Missouri.....	6,391	115	1.83	6,737	115	1.02	18.3
Upper Arkansas-White-Red..	2,976	257	6.99	3,645	238	6.99	10.0
Western Gulf.....	5,621	181	1.03	6,164	181	3.02	16.8
Upper Rio Grande-Pecos....	1,390	24	1.75	1,462	24	1.66	4.0
Colorado.....	2,887	-21	-0.75	2,807	-29	-1.03	7.7
Great Basin.....	2,192	51	2.38	2,366	62	2.77	6.4
Pacific Northwest.....	5,259	105	2.04	5,587	112	2.04	15.3
Central Pacific.....	6,889	121	1.78	7,252	121	1.69	19.8
South Pacific.....	672	-18	-2.66	607	-23	-3.73	1.7
Western mainland.....	34,277	668	1.98	36,627	668	1.86	89.8
48 States.....	37,552	774	2.10	40,768	774	1.95	100.0
Hawaii.....	143	1	1.02	148	2	1.12	0.4
U.S. Total (excluding Alaska).....	37,695 ^{1/4}	775	2.05	40,916	775	1.94	100.0

^{1/} All annual regional acreage increases are individually rounded to nearest 1,000 acres and may not add exactly to totals.

^{2/} Percentages of components of Eastern mainland add to 100, as do those of Western mainland. The percentage figures shown for the total Eastern mainland and for Western mainland were calculated as percentages of total mainland area. Hawaii's irrigated acreage was calculated as a percent of the United States, excluding Alaska.

^{3/} Less than 1,000 acres.

^{4/} Add 158 acres for Alaska in 1964.

2.5 Flood Plains

At the present time, there are no nationwide data on land use in flood plains, and in fact, the nation's flood plains themselves are not well defined.

Maps showing areas subject to flooding have been developed for some 300 localities. These maps cover about 5,400 square miles or about 3% of the estimated 180,000 square miles in flood plains in the United States. These maps delineate flood-risk zones, but do not describe the activities or the structures in the flood plain. Such information is essential to the development of land use indicators of environmental quality.

The Corps of Engineers, the Department of Agriculture, and more recently, the Department of Housing and Urban Development, are involved in collecting data on flood plains. The Corps gathers its data during feasibility and engineering studies for water resource development and flood control projects. Corps surveys^{1/} are unlikely to provide repetitive annual coverage. The USDA collects data through its River Basin Surveys and watershed planning programs.^{1/} HUD has recently become concerned with flood plains because it administers the national flood insurance program. As of the present time HUD has not collected any data on land use in flood plains, though it is being considered.

Most of the data on land use in flood plains were gathered as part of isolated local studies. Comparing data from study-to-study is, therefore, extremely difficult.

A further discussion of the kinds of flood plain data which are required, and recommendations for improving data collection is contained in Section 3.0. Appendix IV contains additional information on flood plain data.

^{1/} See Appendix I

2.6 Wetlands

Fairly complete nationwide wetlands data was collected in a single study published by the U.S. Department of Interior in 1956.^{1/} The 1956 survey by the U.S. Department of the Interior Fish and Wildlife Service (Circular No. 39, Wetlands of the United States) makes reference to surveys conducted in 1906 and 1922 and relates the difficulties in comparing these data over time. Because previous surveys were incomplete or inconsistently categorized wetlands, estimates of the loss of wetland acreage over time are difficult to make. Nevertheless, Table 2.6.0, taken from the 1956 national wetland inventory report (USDI Fish & Wildlife Circular No. 39), attempts to show reduction in wetland acreage since 1850 for seven selected states. Up to 1956, seventeen million acres of original wetlands had been lost in those states. For the country as a whole the USDA estimated that "45 million acres were reclaimed by a combination of clearing drainage, and flood control enterprises" and that those reclaimed lands were "now devoted to crops, pasture, and other dry-land uses."

Table 2.6.0, or one similar to it showing wetland acreage changes over time for all states, in and of itself, could be an indicator of environmental quality. Both the Executive Office and the Congress have indicated concern for preserving the nation's wetlands as an irreplaceable national resource which have a vital role in our ecology. Conversion of a wetland for whatever purpose may, therefore,

^{1/} In 1906 the USDA made an inventory of wetlands, but a substantial area was excluded, thereby providing an incomplete picture at the national level. Again in 1922 the USDA conducted a second wetlands inventory. Data for this project was provided by the U.S. Bureau of Public Roads, and was also extracted from USGS topographic maps, soil survey reports, and the 1920 census of drainage.

be considered a national loss.

Table 2.6.1 shows wetlands land use data as an indicator of environmental quality dependent upon the value judgment of experts in a specific field, in this case, waterfowl authorities. Jamaica Bay in New York, has continued, if not to flourish, at least to do substantially more than just survive as a wildlife sanctuary despite the large quantities of pollutants, both air particulates and water, continually being deposited in the Bay. The environmental quality with respect to water, is degraded, but with respect to wildlife, appears to be relatively little changed. This case illustrates the difficulties inherent in creating land use indicators of environmental quality in wetlands.

While it is possible to obtain data for selected eastern states, no nationwide data was found listing acreage of wetlands destroyed by dredging, construction of buildings, surface mining, solid waste disposal, or for other uses. Good indicators of environmental quality could be established if data by State, over time, could be collected giving not only acreage losses, but also the cause of the loss and the rate at which acreage losses are taking place.

A 1964 resurvey of coastal wetlands was conducted by the Northeast Region, Bureau of Sport Fisheries and Wildlife, with the help of the State fish and game agencies. Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, and Rhode Island and Long Island in New York were studied. Table 2.6.2 is an example of the data collected at that time, and Table 2.6.3 lists causes of wetland loss, previously mentioned as a useful indicator of environmental quality if collected on a regular basis at the state and county levels.^{2/}

^{2/} A number of states (Connecticut, Florida, Maryland, Massachusetts, and New Jersey to mention a few) have enacted laws to protect their coastal and interior wetlands. Intense pressure on wetlands, principally

TABLE 2.6.1 -- Values of Wetlands to Waterfowl, Based on State-Unit Determinations [In acres. Values not comparable between States]

State	Average with value assessed as--				Total
	High	Mod-rate	Low	Negligible	
Alabama.....	26,500	249,600	1,092,200	230,100	1,598,400
Arizona.....	16,500	11,400	500		28,400
Arkansas.....	926,600	699,400	1,496,700	662,700	3,785,400
California.....	317,800	176,200	57,600	7,700	559,300
Colorado.....	35,800	101,600	211,900	55,100	404,400
Connecticut.....	6,900	8,000	4,800	3,700	23,400
Delaware.....	24,600	40,700	49,600	16,400	131,300
Florida.....	423,000	1,659,900	6,585,200	8,517,200	17,185,300
Georgia.....	20,900	440,400	1,428,900	4,029,300	5,919,500
Idaho.....	59,300	23,100	21,400	5,100	108,900
Illinois.....	75,700	196,100	112,700	42,800	427,300
Indiana.....	151,600	68,900	33,600	29,300	283,400
Iowa.....	57,100	51,600		29,400	138,100
Kansas.....	120,800	65,900	17,500		204,200
Kentucky.....	84,400	27,400	34,200	127,100	273,100
Louisiana.....	706,800	1,706,200	1,092,500	6,141,800	9,647,300
Maine.....	108,500	52,200	140,300	80,300	381,300
Maryland.....	112,600	87,800	51,100	38,500	290,000
Massachusetts.....	46,600	55,700	80,200	49,200	231,700
Michigan.....	310,500	2,013,200	430,100	463,300	3,217,100
Minnesota.....	1,274,500	778,800	2,991,600		5,044,900
Mississippi.....	316,200	682,200	854,700	736,300	2,589,400
Missouri.....	105,700	93,100	74,000	104,100	376,900
Montana.....	29,100	113,300	45,000		187,400
Nebraska.....	197,800	171,000	281,000		649,800
Nevada.....	109,100	70,400	13,000		192,500
New Hampshire.....	5,700	4,800	1,700	1,300	13,500
New Jersey.....	127,500	109,100	32,400	900	269,900
New Mexico.....	24,500	12,900	11,100		48,500
New York.....	99,800	35,700	55,100	22,200	212,800
North Carolina.....	81,100	38,500	505,200	3,429,800	4,054,600
North Dakota.....	554,900	653,600	314,800		1,523,300
Ohio.....	38,500	12,300	19,300	27,800	97,900
Oklahoma.....	18,500	133,800	127,400		279,700
Oregon.....	246,000	76,800	131,900	17,900	472,600
Pennsylvania.....	8,600	15,100	15,800	13,400	52,900
Rhode Island.....	1,900	2,100	4,000	17,400	25,400
South Carolina.....	10,900	194,400	1,495,600	1,676,100	3,377,000
South Dakota.....	161,400	414,200	176,400		752,000
Tennessee.....	447,600	128,200	128,600	123,600	828,000
Texas.....	586,400	1,597,800	923,500	633,300	3,741,000
Utah.....	249,400	342,100	315,800	267,100	1,174,400
Vermont.....	6,700	9,500	13,000	8,900	38,100
Virginia.....	28,300	85,900	177,700	249,200	541,100
Washington.....	54,300	53,900	68,100	56,900	233,200
West Virginia.....	1,600		2,200		3,800
Wisconsin.....	389,500	48,200	2,352,900		2,790,600
Wyoming.....	11,900	3,500	14,900		30,300
Total.....	8,819,900	13,616,500	24,087,700	27,915,200	74,439,300

Source: Wetlands of the United States, Their Extent and Their Value to Waterfowl and Other Wildlife; Fish and Wildlife Circular #39, 1956.

TABLE 2.6.2 -- Acreage of Coastal Wetlands Lost, Delaware, 1954-1964.

County	1954 Acreage	Losses 1954-59	1959 Acreage	Losses 1959-64	1964 Acreages	Total Losses 1954-64
New Castle	25,845	2,676	23,169	1,056	22,113	3,732
Kent	60,230	144	60,086	2	60,084	146
Sussex	33,986	328	33,658	354	33,304	682
Totals	<u>120,061</u>	<u>3,148</u>	<u>116,913</u>	<u>1,412</u>	<u>115,501</u>	<u>4,560</u>

Source: Supplementary Report, June 1965, on the Coastal Wetlands Inventory of Delaware. USDI Fish & Wildlife Service, Division of River Basin Studies, Boston, Mass., June 1965

Cause of Loss	County (Acres)							
	New Castle				Sussex			
	1954-59	1959-64	1954-59	1959-64	1954-59	1959-64	Acres	Percent
Miscellaneous Fill*	1,884	0	0	0	0	0	1,884	41.32
Bridges, Roads, Parking	0	1,056	0	1	1	13	1,071	23.49
Industry	690	0	140	0	0	0	830	18.20
Housing	0	0	0	0	307	89	396	8.68
Marinas, Docks, Channels	0	0	3	0	18	98	119	2.61
Waste disposal	102	0	1	0	2	0	105	2.30
Mosquito control	0	0	0	0	0	101	101	2.21
Recreation	0	0	0	1	0	53	54	1.19
Totals	2,676	1,056	144	2	328	354	4,560	100.00

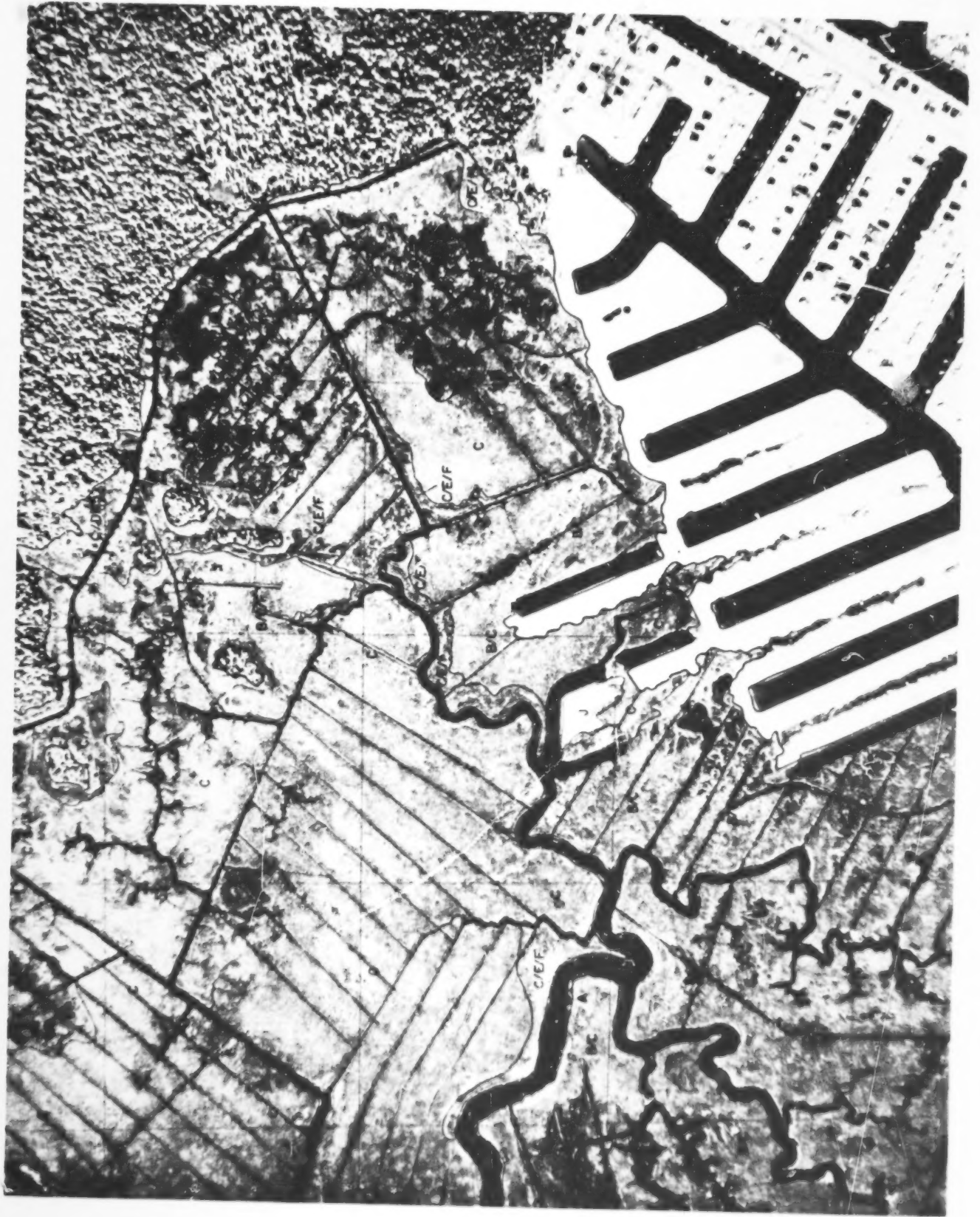
* This term was used when ultimate use of the filled area was unknown.

TABLE 2.6.3 -- Causes of Coastal Wetland Losses, Delaware, 1954-1964

Source: Supplementary Report, June 1965, on the Coastal Wetlands Inventory of Delaware, USDI Fish & Wildlife Service, Division of River Basin Studies, Boston, Mass., June 1965

The character of the wetlands, their location, and the difficulty in collecting acceptable ground data, except on a sample basis, together with the frequently high assessed value of this land, reinforces this conclusion.

2/ (continued) from the development of vacation communities and from water pollution, has resulted in vigorous state action. The regulatory programs require some form of mapping to determine those wetland areas to be subject to regulation. These maps can provide large amounts of data on land use and the wetlands environments. New Jersey, for example, is producing wetland maps, Figure 2.6.0, which delineate the wetlands, the principal plant species associations (which is useful for determining the productivity of the wetland) and record the cultural pressures on the wetlands. Aerial photography is being used to produce the New Jersey maps. A rapid assessment of change can be provided by subsequent aerial surveys at low cost.



2.7 Transportation

The data on land use for transportation clearly illustrate some of the inherent shortcomings of the areal data collected by the Federal Government. Historical data on transportation provide information (nationwide and by state) on the mileage of highways and roads, the amount of land devoted to rail transportation and airports, and a variety of user data such as highway traffic volume, intercity freight traffic, and passenger traffic. Very gross national assessments of the impact of transportation-land use on the environment can be made from such data, but different kinds of data are required for regional or local assessments. See Appendix V.

The most significant environmental characteristic of roads is their location. The fact that there are 243,450 miles of municipal and rural highways in Texas is not by itself particularly useful for assessing environmental quality. The location of these highways with respect to other land uses, and with respect to changing land uses is, however, significant. Where there are highways and roads, land is used more intensively. This is not to suggest that road building precedes or causes increased urbanization or more intensive use of land. It may be that moving population centers demand better roads. Resolving which comes first is beyond the scope of this report, though a correlation between the intensity of land use and the presence of roads is apparent.

Traffic volume on urban streets is also significant, but it must be considered with other data on the urban environment, such as air quality and noise.

The Department of Transportation requires local and regional transportation planning agencies to develop land use data as part of the continuing transportation planning requirements. These data provide the kinds of information on urban land use which would be useful in developing urban indicators of environmental quality. These data are not available, however, in a consistent form on a nationwide basis. (See Section 1.3)

Table 2.7.0 shows the amount of rural highway mileage in the U.S. since 1930. In a strict sense, these are not areal data, though it is possible to develop areal data from the material on which this table is based. The table shows about a 3% change in total mileage.^{1/} Such changes do not reflect the more dramatic impact of the automobile on the environment. Traffic volume and fuel consumption figures provide better data on the increasing impact of the automobile on the environment than do data on the amount of land devoted to transportation.^{2/}

Table 2.7.0 -- Highway Mileage of Rural Roads (In thousands)
1930-1969

TYPE AND CONTROL	1930	1940	1950	1960	1965	1966	1967	1968	1969
All rural roads.....	3,000	3,000	3,000	3,138	3,183	3,188	3,184	3,182	3,182
Primary State highways.....	524	529	583	405	414	418	424	425	406
Secondary State highways.....	-	81	86	105	112	114	112	113	121
County roads under State control.....	-	114	122	136	137	138	138	139	152
County and local roads ¹	2,685	2,468	2,417	2,472	2,520	2,518	2,510	2,475	2,483
Surfaced rural roads.....	694	1,340	1,479	2,165	2,302	2,321	2,338	2,362	2,391
Primary State highways.....	237	302	351	399	410	414	420	421	409
Secondary State highways.....	-	62	73	100	106	110	108	109	117
County roads under State control.....	-	55	83	111	119	120	120	122	135
County and local roads ¹	457	918	1,172	1,655	1,666	1,672	1,688	1,710	1,736

- Represents zero. ¹ Includes mileage in national and State parks, forests, reservations, etc., not included as part of State or local systems.

Source of tables 886 and 887: Dept. of Transportation, Federal Highway Administration; annual report, *Highway Statistics*.

- ^{1/} As a matter of fact, there has been very little change in the total amount of land devoted to transportation in this century.
- ^{2/} Rule of thumb conversion factors have been used to derive areal data from transportation mileage tables. These conversions were not made here because their reliability seemed doubtful.

While the amount of land devoted to transportation has remained fairly constant on a nationwide basis, the amount of land devoted to highways in urban areas has increased dramatically, and along with it, the amount of land for parking and servicing automobiles. Table 2.7.1 shows a 70% increase in municipal highway mileage between 1950 and 1969. This emphasizes the need for data on transportation use in urban areas.

Table 2.7.1 -- Rural and Municipal Highway Mileage
by Government Control - 1930-1969

(In Thousands)

MILEAGE AND CONTROL	1930	1940	1950	1955	1960	1965	1966	1967	1968	1969
Total mileage	(NA)	(NA)	3,313	3,418	3,546	3,600	3,698	3,796	3,884	3,716
Rural mileage.....	3,609	2,990	2,990	3,045	3,116	3,153	3,158	3,184	3,152	3,121
Under State control.....	324	324	581	619	659	667	635	699	702	704
Under local control.....			2,326	2,333	2,345	2,346	2,333	2,321	2,275	2,275
Under Federal control.....	2,085	2,085	73	98	112	180	180	164	175	182
Municipal mileage	(NA)	(NA)	223	373	430	507	510	521	532	545
Under State control.....	(NA)	27	36	42	50	55	55	55	55	72
Under local control.....	(NA)	(NA)	287	331	380	452	455	466	477	473

Existing data on transportation-land use have little value for indicating environmental quality. Data are needed which spatially relate transportation networks and their use with other land uses and with other environmental factors, such as air quality, noise, and congestion.

2.8 Overall Shifts in Major Categories of Land Use

It was originally intended to summarize data presented in Sections 2.1 - 2.7, (a) to examine the usefulness of these data when considered together for indicating environmental quality, and (b) to examine urban land use data since urban land use was not specifically identified among the other categories.

As the study proceeded, it became apparent that existing data could not be consistently and meaningfully analyzed as indicators of environmental quality. The problems of inconsistent definitions among agencies, incomplete data, the differences in data parameters, and the seemingly endless variety of data formats, made the task difficult and the value of the product doubtful. Therefore, rather than try to construct tables which show overall changes in land use from land use data from various agencies we have drawn upon some of the land use data aggregations of the Department of Agriculture to illustrate the nationwide data available on overall shifts in land use, and to assess future needs. (Appendix VI and Section 3.0 contain a more detailed description of the data available.)

This section will also discuss urban land use data as was originally intended.

2.8.1 Urban Land Use

Nationwide data on the overall use of land in urban areas, and in the rapidly changing rural-urban fringes, is all but nonexistent.

The Bureau of the Census collects data on housing, transportation, industry, commerce, and population. These data are aggregated nationally, by region, state, county, city and Standard Metropolitan Statistical Area (SMSA). The periodic surveys by Census are the

principal source of nationwide data on urban areas. (These data will be discussed later in this section.) The Department of Housing and Urban Development (HUD) and the Department of Transportation (DOT) also collect data on urban areas as part of the planning requirements they place on local and metropolitan governments. These data, though they have a common purpose, are highly inconsistent from locality-to-locality because of differences in interpretation, capabilities, resources, problems and emphasis of local governments. Data submitted to DOT by Standard Metropolitan Statistical Areas (SMSA) as part of the continuing planning requirement of the Transportation Act of 1962, is stored on magnetic tape; nevertheless, national aggregations of these data would be difficult since local agencies are encouraged to adjust data definitions to suit local needs. The HUD data present similar problems.

Consistency is far less of a problem when dealing with Census data. Every effort is made to keep these data nationally consistent. This is not to say that problems of consistency (in defining housing quality from one region to another, for example) do not arise. The problem with Census data as far as land use is concerned is that these data cannot be correlated to a particular parcel of land. If they could, knowledge of land use in urban areas would be advanced markedly. The Census Bureau is presently pursuing the technical research necessary to make such geographic correlations feasible. Legal problems regarding the confidentiality of Census data may limit their usefulness once the technical problems have been solved. General government-wide access to land use/environmental quality data will be required because of the

number of agencies conducting environmental programs, and this may pose problems with Census data.

The Geographical Applications Program of the Department of the Interior has initiated a major program to gather land use data for selected cities. This program, the "Census Cities Project," will rely on high altitude aerial photographs for land use data, and for making base maps and overlays. Initial baseline photography for the 26 cities (urban and regional areas) was collected during the summer of 1970. Data collection was intended to correspond to the 1970 decennial census. Land use maps and overlays for these cities will be contained in loose-leaf Atlases of Urban and Regional Change. At the time this report was prepared, actual land use maps or other data for the Census Cities were not yet available.

Though it is perhaps premature to judge the results of the Census Cities Project, certain aspects of the project are worth noting.

- The Project is using Census Data, the basic areal data unit being the census tract, and, therefore, draws upon a continuing historical record of useful data. These data are also unquestionably the most reliable nationwide data on urban areas.
- High altitude aerial photography is being used to do initial land use classification, to develop base maps and overlays, and will be used for change detection. This will enable regular and timely updating between censuses and at fairly low cost.

Data on housing quality, open-spaces, blighted areas or a number of other land uses in urban areas has not been sought. Some nationwide data are available on these subjects, but they do not provide the spatial information which is essential to assessing the environment in urban areas.

For example, if it is known that 70% of the housing in a city is sub-standard, it is not hard to assess that urban environment. Fortunately, our cities are for the most part better off than that. There are, however, neighborhoods with 70% substandard housing within cities where 80% of the housing is sound. It is not the cities with an abnormal rate of substandard housing which must be identified, but the neighborhoods. They are where the changes are taking place and where remedial action is required.

The following tables and charts were prepared by the Economic Research Service of the Department of Agriculture and were published in the Department's quinquennial analysis of land use, Major Uses of Land and Water Resources in the United States with Special Reference to Agriculture.

Figure 2.8.0 presents in graphic form gross data on land use for 1900-1964 and illustrates one of the shortcomings of high level aggregations. Nationwide changes over the 64 year period do not appear to be very significant and that is especially true in view of the fact that the nation's population increased by more than 250% during the period. There were, however, dramatic regional and local land use changes during the period, including, for example, the development of the Boston-Washington Megalopolis, the clearing of hundreds of thousands of acres of southern forests, and the rapid urbanization of California.

Tables and charts, such as 2.8.0, which show nationwide changes in land use for a specific period of time, are common, but they are not very useful. In some instances, the supporting data can be useful for indicating environmental quality as shown in earlier sections. The availability of national aggregations of land use data does not mean

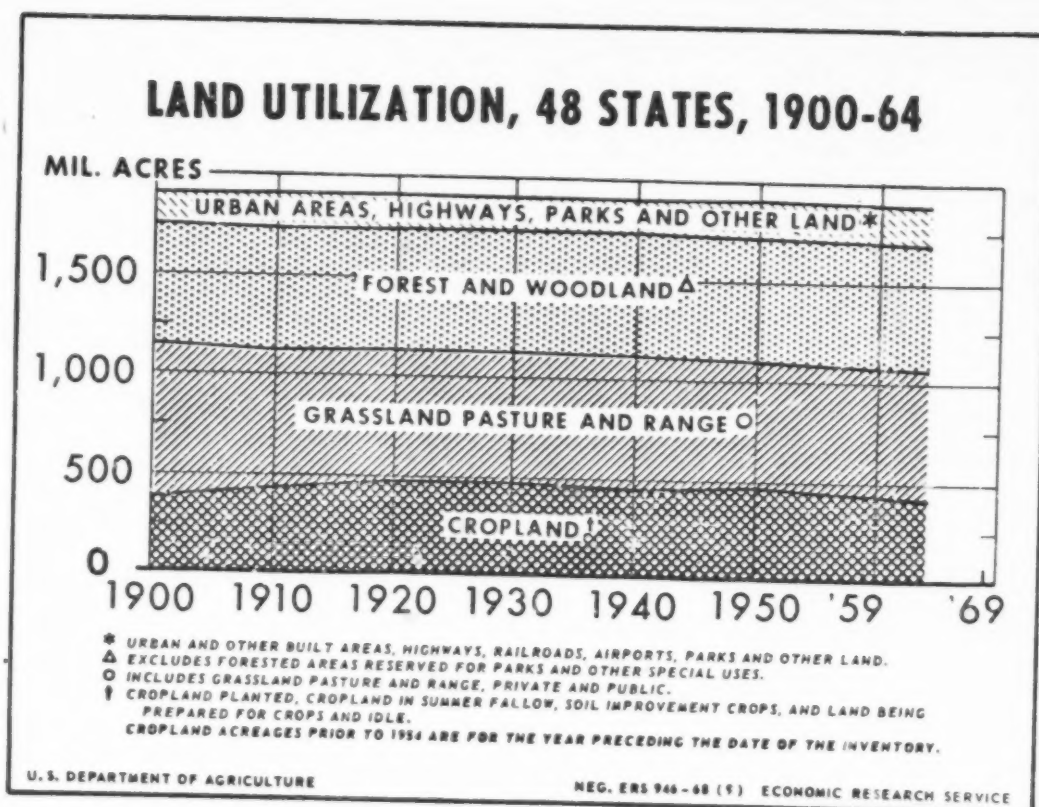


FIGURE 2.8.0

Source: Major Uses of Land and Water in the United States
With Special Reference to Agriculture; Summary for 1964

that meaningful or reliable disaggregations of those data can be made. Errors which cancel each other as data are aggregated are an increasing problem as are disaggregated data. The greater the disaggregation, the greater the error factor will be. It is, therefore, a mistake to assume that because reliable data are available at one level of aggregation, or for one class of land use, that smaller and more useful elements of these data can be extracted from the whole.

Table 2.8.1 shows major land use in 1964 and provides, in addition to the data, definition of the common categories and sub-categories used by the USDA. It is important to note that while changes in definitions may have little nationwide significance, they can account for dramatic regional or local changes. Reclassification resulting from a changed definition or procedure is usually footnoted, and while this is helpful, it does not make the data less difficult to work with.

Nationwide data on overall changes in land use are not available in sufficient detail, consistency, or accuracy at a low enough level of aggregation (statewide data in this instance might be sufficient) to provide useful information for a land use environmental quality information system.

Table 2.8.1 -- Uses of Land, United States, 1954

Major land use	Acreage	Percentage of total
	Million acres	Percent
Agricultural:		
Cropland:-----	444	19.6
Cropland used for crops <u>1</u> /-----	(335)	(14.8)
Soil improvement crops and idle cropland:-----	(52)	(2.3)
Cropland used only for pasture-----	(57)	(2.5)
Grassland pasture and range <u>2</u> /-----	640	28.3
Forest land grazed-----	225	9.9
Farmsteads, farm roads-----	9	.4
Total agricultural land-----	1,318	58.2
Nonagricultural:		
Forest land not grazed <u>3</u> /-----	507	22.4
Special uses:-----	164	7.2
Urban and other built-up areas <u>4</u> /-----	(55)	(2.4)
Primarily for recreation parks and wildlife <u>5</u> /-----	(76)	(3.4)
Public installations and facilities <u>6</u> /-----	(33)	(1.5)
Miscellaneous land <u>7</u> /-----	277	12.2
Total nonagricultural land-----	948	41.8
Total land area-----	2,266	100.0

1/ Cropland harvested, crop failure, and cultivated summer fallow.

2/ Excludes cropland used only for pasture.

3/ Excludes 28 million acres of reserved forest land and 2 million acres of unreserved forest land duplicated mainly in parks and other special use areas. It was not feasible to eliminate some overlap that exists because of multiple use.

4/ Urban and town areas; highway, road, and railroad rights-of-way; and airports.

5/ National and State parks and related recreational areas, National and State wildlife refuges, and National Forest wilderness and primitive areas.

6/ National defense (including military reservations and other land administered by Department of Defense), Federal flood control, Federal industrial (AEC land, etc.), and State institutional areas.

7/ Marshes, open swamps, bare rock areas, deserts, tundra, and other land generally having low value for agricultural purposes.

Source: Major Uses of Land and Water in the United States with Special Reference to Agriculture; Summary for 1964.

3.0 Development of Land Use Indicators of Environmental Quality Using Existing Data

The Council of Environmental Quality requires relatively gross data on environmental quality because it is concerned with the broad national implications of a changing environment. Existing data sources initially appear useful for developing land use indicators of environmental quality for such an overview. However, as Section 2.0 illustrates, the Federal Government cannot rely exclusively on existing data sources because of their inconsistency, high level of aggregation, lack of geographical (spatial) specificity, and unsuitability for the task of defining land use indicators. The absence of agreed upon conventions with respect either to consistency, levels of aggregation of data, or the types of data required, that is, their suitability for environmental indicators, is a fundamental problem.

Before addressing the development of indicators, it is necessary to briefly review the shortcomings of existing data to lay the foundation for the attributes of the data needed for monitoring environmental quality through the use of land use indicators.

This will be done by considering consistency, level of aggregation, and suitability of data. In examining these aspects of data, four principal problems appear. All relate to the resolution (fineness of subdivision or level of detail) of the information with respect to space (or geographical area, acres), categories (classification, units and subdivision), intensity (quantity values such as numbers or volumes) and time (frequency of observation). As far as historical data are concerned, there are very few categories of land use data for which there have not been changes in the boundaries of

the data collection districts, and very few classifications for which there have not been repeated changes in categories and definitions including the addition and later abandonment of particular classes of information. Paralleling these changes are vast differences in the intensity and timeliness of data collection. Much of the data are collected quinquennially in the U. S. Census of Agriculture, the bulk of which appear of only marginal use as inputs to a decision process in environmental quality. Some of the most urgently required data on idle land in the vicinity of major urban centers are not collected adequately by any agency despite the fact that this is land for which significant investment decisions will be made normally within a few years.^{1/} Other areas will have a single special purpose survey separated by many years from a comparable survey. Yet others use statistical sampling procedures which are valid only for fairly high levels of data aggregation and, therefore, are not internally consistent at low levels of data aggregation.

The general questions of resolution and data aggregation are also of concern. The principal problem facing the government administrator dealing with land use related environmental problems is that he cannot talk about deteriorating quality of the environment without specifying where, when, how and in what quantity. Consequently, geographical or spatial information with respect to the environment must be obtained at a relatively fine scale of observation and recording. Yet much of our data are collected in ways in which we cannot address the problem at the action level, which is normally at a relatively fine rather than at a gross geographical scale. For example, data on forest use and resource are collected through a very carefully planned and statistically valid data collection procedure involving sampling.

^{1/} See M. Clawson, C. Stewart, Land Use Information: A Critical Survey of U. S. Statistics, 1965, Johns Hopkins University Press.

The sampling is both stratified and randomized in such a way that about every four-to-eight years the major timber producing states are resurveyed. On about a 10 year cycle, using projections and updating procedures but not resurveying, new country-wide data are prepared. For portions of the United States, the distribution of sampled plots is such that the samples may give a valid picture of forest yields and problems at about the county level of generalization. However, this is not true for much of the country where three-to-ten or more counties may need to be aggregated in order to have enough sample points that the data meet the appropriate tests of representiveness of the area they are sampling. This statistical procedure also does not allow the U. S. Forest Service to address immediately environmental problems for which spatial data are needed. For instance, timely information on areas of critical disturbance, such as insect infestation, cannot be obtained using present procedures. Yet these are precisely the type of data needed for environmental decisions.

Clawson and Stewart^{2/} note, for instance, that "land use data for agriculture have some rather serious shortcomings. First of all, the data are typically summarized by geographic areas too large for some kinds of economic analysis (for economic analysis, also read environmental analysis); the USDA data are national, regional and state; the census of agriculture data are the same with the addition of county data and unpublished data by minor civil divisions. Secondly, the data about agricultural use of land have been imperfectly related, one to another, in spite of the great progress in this direction, as a result of efforts by Census and Agriculture. Thirdly, it seems fairly clear there is a serious hiatus in the land data for the

^{2/} Ibid.

broad ring around cities. This land is no longer, in most cases, within farms; hence, it is not included in the census of Agriculture nor within most USDA statistics."

This problem is difficult enough with areal statistics. However, it is even more serious for those types of data required for environmental impact studies and for aiding decisions on environmental policy where point information is needed. There are many uses of land which are both widely scattered, and occupy only a small area, but which have considerable environmental impact. Frequently, neither the location nor area of such uses is known. This certainly applies to most data on surface land mining, oil wells, settling ponds, and feed lots, for example.

The preceding discussion has emphasized that when data are highly aggregated or employ very coarse resolution in the spatial, category, intensity and time domains, that such data characteristically suffer from a number of major defects. Aggregation is accompanied by, in most instances, a notable loss in sensitivity, which arises from low levels of quantity (intensity) and excessive lumping in categories, from a distinct lack of timeliness of the data because data are taken at too widely separated or irregular intervals, and from an extreme loss of spatial (geographical) variability. In short, the problem of highly aggregated data obtained with a too coarse resolution arises because most environmental problems, although of national concern, must be addressed at local and regional levels, and hence data must be obtainable at these levels. This should not be interpreted to mean that the solution of environmental problems should be the responsibility of local government. Regardless of which level of government takes remedial actions, finer detail is required for those actions, than

for making broad national assessments of the quality of the environment. Data must be finely disaggregated in the spatial, category, intensity and time senses.

As noted earlier, however, merely obtaining a high level of disaggregation in the data is not enough. Data must also be internally consistent with respect to the same four units of space, categories, intensity and time. Variability in land use classifications currently in use between and even within urban areas, make them incompatible from one source to another "even within the same jurisdiction except at an almost meaningless level of summarization."^{3/} The fewer the data, the weaker the relationship to environmental quality or indeed to any other activity using land use data for policy making.

The Council on Environmental Quality faces the problem that many, if not most, existing land use data enable only very coarse, error-prone judgments to be made about environmental quality. Supplementary information, some very detailed, others quite gross, is needed for developing indicators of environmental quality.

In order to employ land use data in decision making on environmental matters, existing data sources are adequate for certain problems only at high levels of aggregation. However, most currently available data are inadequate when employed in remedial action programs at or below the regional level. Since environmental actions are principally taken at regional levels (e.g., river basins), this inadequacy constitutes a serious impediment to the development of dynamic land use indicators of environmental quality.

^{3/} Metropolitan Planning Data from Local Governments: A Demonstration of Land Use Compatibility, 1970, Metropolitan Washington Council of Governments.

3.1 Using Mixtures of Existing Data and Supplementary Data

In order to pursue the use of existing data further and to develop a rationale for employing mixtures of present data collection procedures and supplementary data collection, principally with the use of remote sensing, three areas among those of concern to the Council on Environmental Quality -- Land Use on Flood Plains, Forestry, and Urban Land Use -- will be examined in some detail.

3.1.0 Flood Plains

While flood plain lands make up only some 5% of the land area of the United States, they contain a disproportionately large fraction of the nation's population and tangible property. Both because of the high intensity of urban, transportation and agricultural use as well as the dense populations of the flood plains, they are regions for which a large amount of detailed data on land use is necessary for zoning, reducing the areas of high risk enterprises in regard to flooding, for housing and urban development, insurance programs, flood damage assessment, transportation and irrigation studies, effective sewage control and the development of a program of water pollution and quality maintenance for the urban as well as the agricultural sector.

To indicate the weaknesses of existing land use data with respect to consistency, aggregation and general utility for environmental decisions, a table has been produced for land use for flood plains. For agriculture, urban and rural-urban land use, water bodies, and forestry, the internal consistency of the data and its state of aggregation have been estimated with respect to resolution in space, categories, intensity, and time. In addition, the estimated overall utility of the data for environmental decision making is given along with an estimate of the gain that may come from supplementary remote sensing data.

QUALITY OF EXISTING FLOOD PLAIN LAND USE DATA

	CONSISTENCY				AGGREGATION			ESTIMATED OVERALL UTILITY FOR ENVIRONMENTAL DECISIONS	ESTIMATED GAIN FROM REMOTE SENSING DATA FOR SPATIAL & TIME DATA	TOTAL UTILITY USING PRESENT & POSSIBLE PROCEDURE
	Space	Cate- gories	Inten- sity	Time	Space	Cate- gories	Inten- sity			
Agriculture	2	7	7	8	2	7	7	2	+5	7
Urban Land Uses and Rural/Urban	3	2	2	2	1	4	3	1	+6	7
Water Bodies	3	6	5	4	3	8	8	3	+3	6
Forestry	3	8	7	4	4	8	8	3	+4	7

10, 9 = Very High; 8, 7 = High; 6, 5 = Moderate; 4, 3 = Low; 2, 1 = Very Low; 0 = NIL.

This table is highly subjective and consequently is a method of ordering qualitative judgments as to the relative suitability or otherwise the data for land use information. These are really ordinal data but have been rearranged so that they are in effect a partial interval scale in which zero is Nil, ten and nine are very high in consistency and involve a fine level of data disaggregation and would also indicate a high estimated overall utility for environmental decision making, eight and seven are high, six and five are moderate, four and three are low, and two and one are very low.

Of the four broad categories of land use (agriculture, urban, water, and forestry) agriculture is first examined to see how the table has been constructed.

Agriculture data collected by the U.S. Department of Agriculture and the Census have been collected now for such a long period of time that a high level of formalism and consistency has been reached in regard to data collection categories, amounts of quantities, and the data are also collected on a regular and orderly basis. The stamp of a well organized Federal program, therefore, shows in the high rankings (7, 7, 8) for the internal consistency from state-to-state, county-to-county, for category, intensity and time data. The real weakness of these data is apparent in looking at the spatial consistency constraint. What is meant by this expression is the degree to which available data apply exclusively and

unambiguously to flood plains. The rating of two is very low. A rating of eight would have been given if data were available for collection units the boundaries of which were exactly coincident with flood plains and which could readily be obtained at the smallest reasonable level of aggregation (minor civil divisions). The rating of two simply reflects the fact that while the very largest flood plains may contain a number of counties, all of which are limited to flood plains, this situation is the exception and not the rule. Most flood plains occupy only parts of data collection units. The value two on the national scale might be thought of as a very crude correlation coefficient equal to 0.2. At the national level this may have some limited value; at all other levels, it would be essentially worthless.

The section of the table on aggregation of data contains estimates of the degree to which the data are available in a substantially disaggregated, and hence, greater information carrying capacity. Here again, the orderliness of the Census of Agriculture data is apparent. Data are readily available at the individual crop level with respect to acres planted and harvested and yields on a regular 5 year basis. For some areas and crops, data are available annually and, in some cases, indeed seasonally. Both in categories and intensity, the degree of disaggregation is sufficient to rank high. Because timing is not equally good for all categories, it is estimated to rank as moderate indicating that there are some critical areas of value in environmental studies for which data are obtained too infrequently. The principal problem with respect to data aggregation again reappears as a spatial or geographical location constraint: data are available only at a too high level of aggregation (county) to be suitable for environmental decisions. Typically, most environmental decisions involving land at the block or census tract level,

and even township data (36 square miles) are inadequate for this type of decision making.

In terms of the utility of the existing flood plain land use data, it is apparent that the weakest link, namely spatial data, is the constraint which sets the level of utility of the system. For one reason or another spatial or geographical data are weak for agriculture, urban land use, water body mapping and forestry applications. The timing of the data is also inadequate to greater-or-lesser extent for the different uses while the category and the intensity resolution classes tend normally to be better in both consistency and aggregation. The major exceptions to this general rule (that the spatial constraint is the severe, followed by time) are urban and immediate rural-urban fringe land use data which turn out to be uniformly weak in all classes for environmental applications. Since urban land uses are those requiring the finest detail and the most timely information, it is clear that this is an area of urgency in regard to improving and systematizing data acquisition procedures.

Little purpose would be served by endlessly repeating the detailed problems of consistency and aggregation of data for each of the other land use categories for flood plains. The point has been documented sufficiently to establish the case. For the other areas of concern to the Council on Environmental Quality (wetlands, strip mining and so on) a similar matrix of data infelicity could be constructed and indeed it is a first step to designing more effective data acquisition procedures to meet environmental needs.

The question then arises whether there is any way, short of flooding ourselves with enormously detailed data, more detailed than that of minor civil divisions, to obtain an acceptable improvement in the spatial or

geographical fineness and consistency of our land use data. There appears to be great potential for allying existing data collection procedures at the minor civil division level with additional ground sampling and high altitude aircraft flights at the time of the 5 year agricultural census and the 10 year census of population and so on. This could, where necessary, be supplemented by special aircraft flights and sampling in a multistage design for areas very close to major cities where a finer detail is required. It is estimated that using such procedures, spatial data could be improved by 5 units giving an overall total utility of the improved system of around about 7. (Figure 3.1.0) Short of employing such a supplement to the existing data collection system, sound environmental decisions cannot be made from land use data for flood plains.

3.1.1 Forestry

Forestry data are collecting using a sophisticated mix of aerial and ground sampling, and so illustrate techniques which might be applied to other data gathering programs.

In total, forest area and timber volume data for the United States have a high level of accuracy and acceptability. To date, two to three surveys have been completed for the coterminous United States; Alaska is now in the stages of its first survey.

As many as 300 to 400 sample points per county have been established using a sample frame based upon aerial photography at a scale of three-to-four inches to a mile. A systematic multilevel and multistage sample that begins with a single acre cell as representative of 500 acres is generally used. These 500 acre are in turn subsampled

Figure 3.1.0 was generated from a color infrared photograph. This is a low altitude photograph showing land use in an agricultural/forested region. Color infrared photography has been used to identify crops and trees. The vigor of vegetation can also be determined through the use of this sensor, and since vegetative stress is often an indicator of environmental degradation such as air and water pollution, color infrared can provide valuable inferential data on the quality of the environment. For showing changing patterns, repetitive aerial photographic coverage over time must be gathered and analyzed.

COLOR INFRARED AERIAL PHOTO HIGHLIGHTS LAND-USE FEATURES FOR GEOGRAPHIC ANALYSIS

ASHEVILLE BASIN TEST SITE, WESTERN NORTH CAROLINA

SIGNIFICANT DATA FOR REGIONAL RESOURCE INVENTORY

1. UNHARVESTED CORN ACREAGE
2. HARVESTED CORN ACREAGE
3. CORN LAND PLOWED
4. REFORESTATION
5. DRAINAGE IMPROVEMENT
6. FARM PONDS
7. BROOMSEDGE
8. PERMANENT PASTURE
9. ABANDONED LAND
10. ERODED SOIL
11. RURAL NON-FARM COMPLEX



SCALE: 0 L 1000 FEET

NASA PHOTO NOVEMBER 1965

PREPARED IN COOPERATION WITH: EAST TENNESSEE STATE UNIVERSITY

GEOGRAPHY TASK #2

NASA CONVAIR 240A A/C; NOVEMBER, 1965; ALTITUDE 2000 FT.

NASA SA66-15773

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stereoscopically at about a one-third ratio so that each subsample is extrapolated for 1,500 acres. These subsamples are reclassified as to type with respect to the kind, stand size, stocking rates, and so on. These 1,500 acres are in turn subsampled on the ground so that one acre on the ground as part of the multistage sampling design is representative of 5,000 acres. These ground sites are permanently located and revisited at four-to-ten year intervals depending upon the area and the quality of the forest resources in the region.

Even in the smallest of counties there tend to be 10 to 30 ground locations and some 300 to 400 photo plots per county. The photos used are dated and on the average will be three-to-four years old at the time they are used for the survey.

The national accuracy target statistics for error at one standard deviation are plus or minus 3% per million acres and plus or minus 5% per one billion cubic feet. As a rule of thumb, in the eastern United States, one acre is approximately equal to 1,000 cubic feet and in the western United States, 2,000 cubic feet, so the 5% error for volume is distributed over a million acres or approximately 1,600 square miles in the east and 800 square miles for the western forests. Comparable accuracy figures for growth and cut are 5% and 10%, respectively. States and private companies will add additional funding to reinforce forest service manpower enabling additional data to be obtained. In areas where a very active forestry program is underway, considerable supplementation may be made. Approximately \$3.5 million are spent annually to collect these data on the national forests; another \$3.5 million on other forests, and approximately \$2 million of state and private supplementation is added. The most

expensive part of the data collection is the ground work in which an exhaustive data set involving 60 variables may be measured following procedures codified in the standard forest handbook. Standard computer packages have been developed for working with these data and different computer programs have been developed for working with different sampling designs depending on the forest type.

Because the counties of the United States vary markedly in their size and degree of forest cover, the area needed to meet national accuracy standards will vary from locale-to-locale. In northern Minnesota, for example, Koochiching County alone contains a large enough forest area to meet the national standards at the million acre level. Other smaller counties with modest acreage and forest may need to be aggregated in groups of five-to-ten or more counties in order to meet these standards. In addition, since forest boundaries frequently bear little relationship to county boundaries, the actual locations of forest land represented by the sample is not known.

In order to be able to answer many environmentally related questions on forestry, geographical or spatial information is essential. Without disturbing the existing very valuable data collection procedures, high altitude aircraft survey on a five year repeat cycle would add significantly to the planning and organization of forest extraction.

There are various types of information related to environmental quality on which no data is currently available and for which remote sensing would appear to be a useful supplement to the existing data

collection procedures. Over recent years, the clear cutting procedures in the northwest have come under challenge because some observers believe this type of disturbance is environmentally undesirable, producing, inter alia, excessive erosion. The present data collection system, however, does not enable effective monitoring of clear cutting or any other type of clearing for that matter, to be made on a timely basis. In areas where clear cutting is a standard procedure, aircraft flights at 2 year intervals may be necessary to monitor this type of change. Other timber cutting practices need to be monitored and supplementary low altitude aircraft photography could be used for such monitoring.

Because of the general lack of spatial data in forestry, many options for improved forestry practices, planning and organization for re-planting following moderate fires, landslides, snowslides and insect and fungus kill, are not currently available. The principal problem is delineating areas large enough to be worth reseeding (normally 20 acres or more). There are many changes in the forest lands of environmental significance in blocks between 20 and 200 acres or more, which our present monitoring system is unable to accommodate. The problem is thus one of size and time frame for action. In addition to the other factors mentioned, major storms, floods, damage from ice and snow, snow avalanches, ice storms, and delineation of areas for aerial seeding and dusting, are all inadequately handled with the present data system. Yet in terms of optimizing both forest production and environmental quality, these data needs may well be covered at an acceptable cost with a regular high altitude survey. Since the end uses of a regular high altitude survey will be distributed over many government and private agencies, the cost could be held to a reasonable figure. Improvements in

film, filters and cameras over recent years have been such that it is now in any case a serious question whether much routine aircraft data could be obtained better from high altitude rather than moderate and low altitude surveys. (High altitude is used here as in excess of 40,000 feet, moderate altitude around 20,000 feet, and low altitude 5,000 to 10,000 feet.)

The principal role we see for high altitude aircraft is in supplementing the present forest survey procedures and for monitoring the environment in the spatial or geographical sense at scales of observation which the existing system cannot accommodate. It turns out, in short, that the monitoring of much environmental data is not readily accommodated in the existing system and a mixed system employing additional aircraft data appears to be necessary.

3.1.2 Alternative Data Collection Programs

Before leaving this area, we must also consider possible alternatives not involving remote sensing. For forest surveys, we really see no reasonable way of obtaining spatial, timely data other than by remote sensing data obtained with aircraft and for selected problems, spacecraft. A mere increase in the sampling rate will not recover spatial data. A doubling of the sample would only marginally improve the accuracy of our statistics, would almost double costs and still not meet the need for spatial data which is essential for environmental decisions or for improved management of forest lands.

A somewhat different conclusion is reached with respect to using census of agriculture data. These data are now collected using a mailed questionnaire, whereas in earlier years, census enumerates were used. Questions on minor civil division locations within the county are asked, but answers are not required, and at present, it is not possible to deal with data below the county level. We believe there is justification for a study of the advantages and costs of collecting mail census data with required minor civil division enumeration. Such data when allied with high altitude aircraft images, or indeed, even some spacecraft images, would enable the minor civil division statistics at the first digit level to be spatially allocated on images of the same year. For particular areas and problems, spatial allocation could provide some second and even third digit data. A mixed system involving improvement of existing procedures plus remote sensing thus appears worthy of study for agriculture.

3.1.3 Urban Areas

The major problem with land use data for urban areas is the familiar one of inconsistency between multiple jurisdictions. Photography can prove highly consistent for individual urban areas, and it appears likely to provide suitable data for planning management decisions, and for the development of environmental indicators.

Based on 1972 prices, the acquisition cost of commercially-obtained color infrared photography at a scale of 1:80,000 (flying height - 40,000 feet, 6" mapping camera) will range between \$4 to \$10 per square mile of stereoscopic coverage ^{4/} depending upon the size of the area, its location and general weather conditions. An approximate cost for acquiring aerial photography for the Washington, D.C. metropolitan area would be \$10,000 for an area 50 by 50 miles on a side (2,500 square miles). Depending upon the type of urban land use data to be obtained from the photography and the methods of coding and storing data, the cost of land use analysis will range from \$20 to \$80 per square mile. The approximate cost per square mile for acquisition of photography and land use analysis would be \$24 - \$90. For the Washington metropolitan area the total cost (based on 2,500 square miles) would range from \$60,000 to \$225,000. (Costs will, of course, be lower for predominantly rural areas.) A complete and thorough mapping at the time of the decennial census with a quinquennial update in between, coupled with annual or biennial repetitive point sampling of the same areas would appear to be a satisfactory procedure in the relatively slowly changing parts of the urban area. This approach should be coupled with detailed aerial

^{4/} Stereoscopic coverage provides overlapping photography. Two adjacent frames may be viewed simultaneously through a stereoscope to extract additional data such as tree height and topography.

photography and mapping of areas of rapid change on a biennial cycle.

The cost effectiveness of this approach for up-dating land use data in urban areas and the immediate rural-urban fringe, is still not known. However, an increasing number of counties and states are looking into the possibility of developing hybrid systems of data collection using traditional, along with remote sensing, techniques. While hard figures are difficult to come by, there appears, however, to be emerging consensus among workers in urban areas that there is a real role for remote sensing in obtaining spatial data at the level of aggregation most pertinent for the planning and management functions.

Dueker and Horton showed that, using 1:50,000, 1:100,000 and 1:382,000 scale color infrared photography of the Washington, D.C. metropolitan area they were able to duplicate, to a high degree, the one-digit urban land use classification employed by the Council of Governments (COG). They reported that: 5/

"The results of this research suggest that in certain cases, and at an appropriate scale the use of remote sensing imagery in obtaining land use information is both useful and desirable. The problems associated with the comparison of the COG data and imagery data are the result of the differential criteria upon which the two data sources are based. Each data source clearly has utility for a variety of purposes. However, land use data can be obtained from imagery in a relatively short period of time and at a lower cost than the collection and aggregation of land parcel data (our italics). The provision of land use inputs for macro models of urban growth and development is both feasible and desirable due mainly to the relatively low costs associated with data collection.

5/ Dueker; Horton: Toward Geographic Urban Change Detection Systems with Remote Sensing Inputs, American Society of Photogrammetry 1971

They continue:

"The potential usefulness of remote sensing in obtaining certain types of change data may provide metropolitan areas with some of the information necessary to develop viable plans for guiding the growth and development of the urban complex. However, in order to maximize the utility of remote sensing, it should be used in conjunction with other data sources. Because of its flexibility and timeliness, the use of remote sensing seems particularly appropriate for updating certain types of information, such as dwelling unit counts, land use change, and urban land use development."

In a series of studies employing this same photography, Mallon (1971, 1972) has found in the COG area that land use housing quality and neighborhood quality data which are generally suitable for COG data files may be obtained from the high altitude photography with sufficient accuracy to warrant further study. Appendix VI contains a more detailed analysis of urban land use needs and the application of remote sensing to data collection.

3.2 Potential Future Systems

Throughout the discussion on land use in flood plains, urban areas, and forestry, the problems of resolution in space, categories, intensity and time with respect to both aggregation and consistency have been encountered over and over again. The absence of spatial data obtained in a timely manner is the most critical shortcoming of existing data sources. Future data requirements will need to correct this imbalance. The exact manner of correcting it will vary from area-to-area and for subject-to-subject. It appears, however, that finer levels of disaggregation using the present techniques will not meet this need except in forestry. First levels of data acquisition will be both costly and difficult to implement. It appears, therefore, that a mixed or hybrid

system combining the present data collection methods with multistage sampling involving ground checks, low altitude aircraft, high altitude aircraft and perhaps in the future, spacecraft data can provide the types of spatial and timely data necessary. (Figure 3.2)

3.2.0 Improvement of Urban Data Collection Techniques

In the time available, it is not feasible to outline the components of a system for each of the land use categories examined in Section 2.0. As an example of the types of data needed, one category, that of the urban land use data, was examined more closely to determine ways in which existing and future data systems employing some remote sensing may work together.

Planning and management in the cities requires great flexibility and compatibility in data formats coupled with reliability and timeliness of the data. The decennial census provides high quality data at the block, and in the future at the block face level, and this could be used as a calibration point for each ten year period in a hybrid system. Census data are now moving to block face format using street address for coding the centroid of the block face and establishing geographical files. Such a procedure will enable both census and remote sensing data to be brought into spatial compatibility. (Figure 3.2.0)

Among the principal items needed for urban planning and management are intercensal population counts, land use data, highway extension, and employment information, particularly on the growing edges of the city. Data are needed at least at two year intervals and in some instances, may be required annually. Urban land use data should be mapped in considerable detail at the time of the decennial census employing both detailed ground

Figure 3.2 is a high altitude photograph (taken at 60,000 feet) of a portion of the Raritan Bay area of New Jersey. The scale is approximately 1:120,000 or two miles to the inch. This is a black and white print generated from a natural color transparency. The synoptic view provided by such high altitude aircraft photographs is useful for studying regional relationships. The encroachment of urban areas on forest lands, agricultural lands, wetlands and the coastal zone can be identified, and repetitive high altitude coverage of the same area over time would show spatial as well as areal changes in these land uses and would identify changes. Photographic resolution is of sufficiently high quality to provide information on changes within general land use categories. For example, new construction within an urbanized area, or changes in agricultural crop types, can be identified at this scale. Source: National Aeronautics & Space Administration.

73C

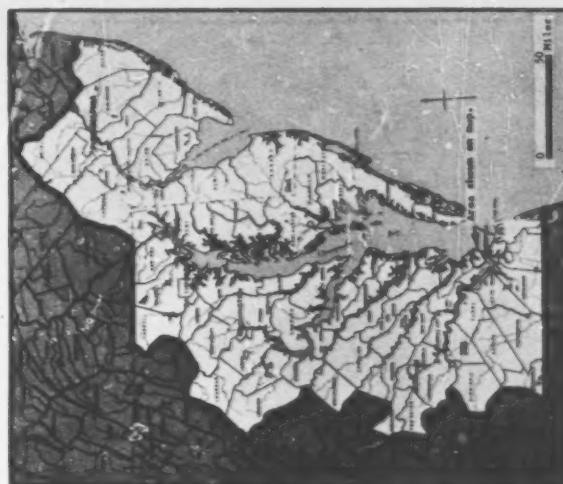


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Figure 3.2.0 shows a land use map constructed through the interpretation of high altitude aircraft photography. Maps such as this provide a permanent record of land use at a given point in time. These data can supplement data from traditional sources, such as the Census of Population, and data which are relatively new, such as on air and water quality. The photo base map provides a means for spatially orienting much of the areal and point data presently collected. For example, the amount and location (particularly with reference to population centers and transportation routes) of open spaces can be determined. Subsequent overflights provide updated records which, when compared with the results of past photoanalyses, will be useful for identifying land use changes and growth trends.



CARETS — Central Atlantic Regional Ecological Test Site



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Statute Miles 0 5

- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Transportation
- Improved Open Space
- Water Recreation
- Cropland
- Forest
- Wetland

USGS/NASA Geographic Applications Program

work and a variety of photographic imagery. Imagery obtained at the time of the census could use the census data for calibration points, as is now being done in the census city project of the Geographic Applications Branch, Department of the Interior. In areas within the city which are changing relatively slowly, a sampling procedure using the same sample points at two-to-three year intervals would provide adequate control on trends in such areas. In the growing edges of cities (Figure 3.2.1), bi-annual updating procedures with detailed mapping could be used to establish the time of development of significant new high intensity land uses, using the same detailed mapping techniques as at the time of the census. An internally consistent data source and data set would thus be in use over a wide metropolitan area involving multiple jurisdictions. These suggestions indicate that it should be possible to develop both detailed mapping and sampling procedures in cities in some internally consistent manner using the census data as a starting point for calibration.

A third broad class of information needed is on the extension of the highway network, in order that the movements of goods and people may be viewed as part of the entire urban system. The value of the highway network derived from photography is particularly enhanced in that street addresses and block faces are being used now for coding geographical files.

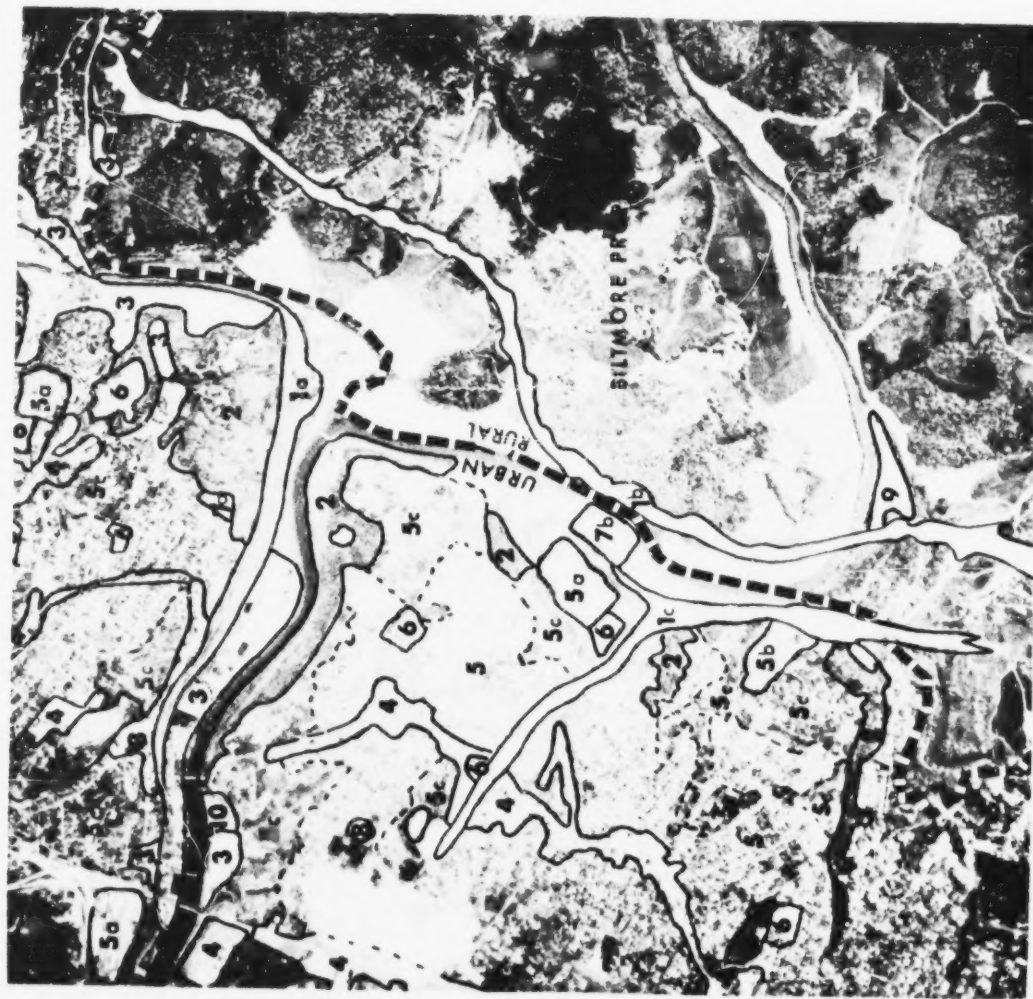
The fourth principal data type needed for management and planning in urban areas is employment data including the journey to work and trip generation data obtained for the first time in the census of 1970.

The preceding four items (intercensal population counts at approximately two year intervals on the growing edges of cities, updating of land use data at about the same time, extension of the highway network at least biannually

746

Figure 3.2.1, which shows broad land use categories and the boundary between urban and rural areas, was generated from a color infrared photograph. Information on the changes occurring at the urban-rural interface is essential to the understanding of land use trends.

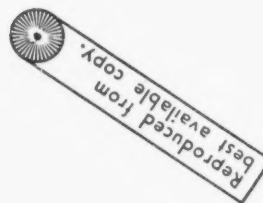
COLOR INFRARED AERIAL PHOTO OF THE ASHEVILLE URBANIZED REGION AND THE BILTMORE ESTATE



LEGEND

BROAD LAND USE CATEGORIES

1. TRANSPORTATIONAL
2. VACANT LAND
3. INDUSTRIAL
4. COMMERCIAL
5. RESIDENTIAL
6. INSTITUTIONAL-SCHOOL
7. RECREATIONAL
8. INSTITUTIONAL- CHURCH



DEGRADED COLOR INFRARED AERIAL
PHOTO CLEARLY DISPLAYS PATTERNS
OF ASSOCIATION OF RURAL AND
URBAN LAND USES.

and preferably annually, and employment data) provide the principal information needed for planning and management in cities. While much additional information is also needed, these are the critical data for decision makers. With the exception of the employment data, it is our judgement that a high level of acceptability for planning and management may be obtained with mixtures of high and low altitude aircraft photography for population, land use and highway network analysis. Employment data, on the other hand, for some time at least, will need to be collected using traditional ground and interview techniques. Important additional information of interest to the urban planner may also be obtained using this same remote sensing data on general change in the urban area and housing and neighborhood quality in particular. Certain sources of solid waste generation may also be determined from the photography.

At present, using manual techniques for data extraction, and the traditional skills of the photointerpreter, it appears that timely remote sensing may provide acceptable data for decision making. A portion of this interpretation job may in the future be capable of sufficient automation to save both time and money. For the immediate future, however, remote sensing will continue to need the skills of the interpreter. Automated data extraction from high altitude imagery offers a good potential for developing indicators of environmental quality.

3.2.1 The Role of Satellite-Devised Land Use Data

Is there a role for satellite-devised land use data as part of a land use information system? Is there a role for satellite data as an input to environmental indices? It is still too early, prior to the launch of the first Earth Resource Technology Satellite (ERTS) in mid 1972, to give more than a "yes, with qualifications" answer to these questions.

A recent study for the Economic Research Service of the U. S. Department of Agriculture entitled Land Use Classification with Simulated Satellite Photography^{6/} examined a number of questions, pertinent to general data collection on land use, but also of relevance to the Council's concern with land use indicators of environmental quality. The questions are:

1. Will the new (satellite) system eliminate the need for conventional land use data gathering systems?
2. Will the new systems merely supplement the old systems, and, if so, to what extent?
3. Will the data from the new remote sensing systems be compatible with data series of earlier years such as those used in the Economic Research Service?
4. Will definitions of major land use categories have to be modified?
5. What are the limitations of expected satellite data in presenting a realistic picture of land use?

The following is a summary of the conclusions based on the simulation of ERTS satellite imagery. The authors estimated the quality of the imagery for land use mapping.

1. The USDA land use classification system currently in use will be compatible with satellite photography, and approximately 90% of the data now required for periodic land use reports can be obtained from satellite photography. "An additional 5 to 8 percent of the required information can be infer-

^{6/} Belcher, Hardy, Phillip, Land Use Classification with Simulated Satellite Photography, 1971, USDA - ERS.

entially derived from satellite photography and supplementary sources."

2. An estimated 2 to 5 percent of the data now included in the periodic reports cannot be obtained from satellite photography including such information as transitional and some multiple-use areas, e.g., pasture-land reverting to forest and cropland used as pasture.
3. Weather conditions are a serious inhibiting factor to the successful use of satellite photography of any type though this limitation would be minimal if the Department's land use reports continue at five-year intervals. High altitude aircraft can provide supplemental data to assure adequate coverage of land use within any one year.
4. Specific land use data can be tied to specific geographic locations and this will greatly increase the value of USDA land use reports.

3.2.1.0 Interpretability of Satellite Data

"Agricultural land," as characterized in the "Land and Water Report," can be identified with varying degrees of success from aerial photographs according to the research performed for the Economic Research Service.^{7/} It should be emphasized that up to the present time, research on satellite photography has been confined to simulated data, weather satellite imagery, and photography from manned space flights. Simulated space photography have been developed by NASA from high altitude (60,000 feet) photography. Space photography from the manned space flights is of a much higher quality than can be expected from near-term earth resources satellites which will rely

^{7/} Ibid.

on television transmission of images rather than the return of exposed film from space. The first earth resources satellite, ERTS-A, will be launched in the Spring of 1972, and until data are available from the ERTS experiments, no firm conclusion can be reached regarding the quality of satellite data. Considerable research with simulated space data has been conducted in preparation for the ERTS mission. Appendix VII contains the summarized findings as to interpretability of the Economic Research Service study previously mentioned.

In mid-1971, the Department of the Interior (U. S. Geological Survey) and the National Aeronautics and Space Administration co-sponsored a Conference on Land Use Information and Classification.^{8/} One of the papers presented discussed some of the criteria for designing an effective land use classification relying on remote sensing data. Since some of the material is highly relevant to this study, it is summarized below:

"Although it is unlikely that complete reliance can be placed on remote sensing techniques for collecting land use data at first- and-second-digit levels, many recent developments hold considerable promise for obtaining much information rapidly and at a low unit cost. Clearly recognized is the fact that such data will not meet all of the needs of the users of land use information.

Some working criteria against which to evaluate land use classification schemes for use with orbital imagery are briefly presented here as a guideline. These criteria apply mainly to a classification scheme developed for use at intermediate scales ranging from 1:62,500 to 1:250,000 for the United States. The potential users of land use information at the indicated scales

^{8/} Anderson, J. R., Land Use Classification Schemes With the Need for Standardization, U. S. Department of the Interior, 1972.

are assumed to be the state and Federal governments and regional organizations.

1. A minimum level of accuracy of about 90 percent in the interpretation of the imagery.
2. A well balanced reliability of interpretation for the several categories included in the classification scheme should be attained.
3. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.
4. The classification scheme should be useable or adaptable for use over an extensive area.
5. The categorization used in the classification scheme should permit vegetative and other cover types to be used as surrogates for activity-oriented categories whenever possible.
6. The classification scheme should be suitable for use with imagery taken at different times during the year.
7. The classification scheme should permit effective use of sub-categories that can be obtained from ground surveys or from the use of imagery available at a larger scale or with the use of such enhanced imagery as color infrared.
8. A need to collapse the categories must be recognized.
9. Comparison with land use information compiled at earlier points in time and data that will be collected in the future should definitely be possible.
10. The classification scheme should recognize the multiple-use aspects of land use whenever possible."

4.0 CONCLUSIONS AND RECOMMENDATIONS

The National Environmental Policy Act of 1969 established the Council on Environmental Quality within the Executive Office of the President and gave it the responsibility for monitoring the environment and for recommending ways to improve existing programs and activities of the government which affect the environment. By examining the development of land use indicators of environmental quality, and in evaluating existing land use data and data collection programs, this study dealt in part with both of these responsibilities.

Meaningful and reliable indicators of environmental quality based on land use and which utilize data currently collected by the Federal Government, cannot be developed. Existing data must be improved to provide greater consistency, regular and repetitive coverage, more timely information, and spatial data. Until land use data are upgraded, indicators which rely on these data can provide only error prone assessments of the quality of the environment.

Assessments of the quality of the environment may require, in addition to sound data, the making of a number of value judgments as to what constitutes environmental quality. The making of such judgments was beyond the scope of this study. It appears, however, that while some values have been and will continue to be established by the Federal Government (the setting of air and water quality standards, for example), these judgments are not essential to improving the quality of the land use data currently collected. For example, it is not necessary to know the optimum amount of open space per capita in urban areas in order to derive significant value from knowledge of the amount, location, and accessibility of existing

open spaces.

It is clear from our investigations that the Federal Government has vast amounts of data on land use and related activities. The machinery for collecting these data is extensive. Automated data processing is used to some degree in the handling of these data by all of the major agencies.

It is also clear that it is extremely difficult, time consuming and costly to regularly extract data from established and operating programs if the data do not conform to the precise specifications established by the collecting agency. Data are collected by the Federal Government to meet specific program objectives, some of which are established by statute and none of which meet the specific requirements of an environmental indicator based on land use.

To provide additional data on environmental quality, the Federal data collection and processing programs must be modified and expanded. Many of the changes are under discussion or consideration, and the Congress is considering legislation which would establish a mechanism for coordinating the environmental data collection programs of the Federal Government.^{1/}

The following actions are recommended: (Detailed discussions for each recommendation are contained in subsequent sections.)

1. The coordination by the Council on Environmental Quality of Federal environmental data collection and processing activities.^{2/}

^{1/} See HR-56, 92nd Congress, 1st Session

^{2/} Even though this study was limited to land use data and does not, therefore provide a substantial basis for including all Federal activities, the assessment of environmental quality requires a single direction to data gathering activities, so that consistency and comparability among data can be assured.

2. Adoption of a standard land use classification system for use by the Federal Government and all state and local agencies providing data to the Federal Government as part of Federal grant-in-aid programs.
3. The development of mixed environmental data gathering programs which rely on existing data and supplementary remote sensing data and which will provide annual data on the state of the environment.
4. Establishment of an environmental data network which will provide automated data processing access within the Council on Environmental Quality to all environmental data collected by the various Federal agencies, and access from agency-to-agency.
5. Coordination by the Department of the Interior of all public and private research funded by the Federal Government on the land use data acquisition.
6. Identification of environmentally distressed areas for intensive data collection, analysis, remedial action and monitoring.

Admittedly, these are not novel recommendations; together, however, they represent an approach to increasing the effectiveness of existing land use data programs within the Federal Government without introducing costly organizational changes in the Federal structure. The remainder of this report elaborates on these recommendations.

4.1 Coordination of Environmental Data Programs by the Council On Environmental Quality

The single most difficult obstacle to the regular compilation of data and information on the environment is the lack of consistency of

data parameters from agency-to-agency and from program-to-program. Land use definitions, map scales, base units, political and natural areas covered, periods of coverage, accuracy, and detail all vary to a greater or lesser extent from program-to-program. Efforts to bring about more consistency are being made by the agencies responsible for collecting much of the data and should be encouraged. However, without greater direction from the Council on Environmental Quality, it is unlikely that fundamental agency differences will be resolved. Without such direction it is unlikely that the existing data programs can or will provide, in addition to their normal outputs, useful data on environmental quality. The Council must adopt and promulgate standards for application throughout the government.

In its deliberations, the Council should consult with all of the concerned agencies and interagency committees. The principal purposes for which data are collected must not be obscured by the need for greater uniformity among various data. The cost of systems modifications, the value of uninterrupted historical records, the need to assure secrecy (with respect to Census and national security data) are some of the considerations which must be made. Only an Executive Office is in a position to weigh individual agency concerns, and the collective benefits of greater uniformity.

4.1.0 Timing

The Federal Government is rapidly developing and expanding automated data processing capabilities and facilities. These efforts are to a large extent prompted by the need to meet the requirement of the National Environmental Policy Act of 1969. The specifications of these systems are

being approved at the present time. Changes, once these systems are fully operational, will be costly. An excellent opportunity exists to build these systems to provide consistent, useful and meaningful environmental data if the Federal Government moves quickly. The Council, with the support of the Office of Management and Budget, has the capability to direct such an effort.

4.1.1 Environmental Data

This study has been concerned only with land use environmental data. Data on air and water quality, pesticides, solid waste disposal, etc. have not been examined. It is therefore beyond the scope of this report to recommend specific actions with regard to these data. The study of land use data does, however, clearly indicate the value of having all environmental data in compatible formats and accessible through an environmental data network. Without such a system, any meaningful analysis of environmental interactions on a nationwide basis will be impossible.

4.2 Adoption of Standard Land Use Classification System

The efforts of the Federal Government and others to arrive at an agreement on land use classification were discussed in the Introduction. This report does not recommend a particular land use classification system. The Geographical Applications Program of the U.S. Department of the Interior has been directing a major government-wide effort to reach agreement on land use classification. A system such as the one which has been tentatively adopted appears appropriate.

There is a need to quickly resolve remaining interagency disagreements on definitions, and to expedite the adoption and promulgation of

land use classification system for application throughout the Federal Government. Such a system should also apply to local programs which generate data for the Federal Government.

The proposed system allows for different levels of information. Operating agencies will continue to collect data to the degree of detail and accuracy required to carry out their responsibilities. Detailed data will be capable of being aggregated upward.

A Federal land use data system should provide for the following:

1. Consistent definition of data categories
2. Compatible data formats and processing techniques
3. Similar geographic, political, or natural area data aggregations
4. Sufficient flexibility to allow collection of detailed data by operating agencies
5. Maximum reliance on existing and developing systems within the Federal Government
6. Computerized data files with multi-user access
7. Reliance on high altitude aircraft and satellite remote sensing for supplementary data
8. Frequent coverage (quinquennial nationwide coverage with annual updating by selective sampling and with more frequent data collection in environmentally pressured areas)
9. Initial data collection to be at a high level of resolution in space, time, intensity, and category, i.e., detailed data at the parcel level form the foundation of the land use data collection system.

Because of the accelerated automation of environmental data files mentioned in Section 4.1, it is essential that uniform classification standards be adopted quickly. Fortunately much of the most difficult work has already been done. Agency differences which are as yet unresolved appear to be so fundamental as to require the guidance of the Executive Office

if they are to be resolved.

The adoption of an uniform land use classification system is only the first step toward achieving compatability among Federal land use data programs. However, until it is achieved, the problems of data formats, degree of detail, processing techniques, and access cannot be resolved.

4.3 An Environmental Information System Relying on Existing Data and Remote Sensing

This recommendation is discussed in detail in Section 3.0. The following briefly summarizes that material:

Some land use data collected by the Federal Government can be used to provide environmental information in their present form, or with some modification.

Remote sensing data can supplement existing data and, often at small incremental cost, provide substantially more information on environmental quality.

4.4 The Establishment of an Environmental Data Network Within the Federal Government

Environmental data will continue to be collected by a number of Federal agencies, since data collection is an essential part of the administration of their individual programs. (For example, soil conservation programs cannot be conducted without regular data collection.) Several measures have been recommended to bring about greater consistency and comparability of data on the environment collected by the Federal Government. This would not only bring some order to the data, but would enable their government-wide use. The National Environmental Policy Act of 1969 requires Federal agencies to carefully consider the environmental

implications of their proposed actions. To meet this requirement, agencies must frequently have access to data beyond their own.

The major data gathering agencies use computers for processing the massive amounts of data they collect. A network which would enable participating agencies to have access to the environmental data files of other agencies should be established.

Major problems inherent to the data must be resolved before the complex technical problems of such an interagency data network can be addressed. However, such a capability is essential to understanding the environment.

4.5 The Coordination of Land Use Research

The Departments of Agriculture, Commerce, Housing and Urban Development, Interior and Transportation have supported a large amount of research on land use during the past ten years. Included are internal government studies, publicly funded university research, private contract work, systems design and demonstration projects. Much of the recent work has been prompted by the earth observation satellite programs. The Department of the Interior, and NASA have provided the leadership in developing satellite systems to meet the earth resources data requirements of the various agencies. The research also reflects a greater interest in the use of remote sensing by the operating agencies.

It is recommended that Geographic Applications Program of the Department of the Interior compile an index of completed research and demonstration projects and coordinate all future land use studies conducted with Federal funds. While the decision to proceed with specific research projects should remain with the funding agencies, some mechanism is needed to:

- Publicize completed research so that more may benefit, and so that

duplication is avoided

- Identify subject areas which need further exploration; and
- Assure that a proper balance is struck between the development of technological systems, and the establishment of geo-political institutions which are capable of benefiting from technological advances.

Most areas of governmental activity could use some coordination; in this instance it is felt that the above recommendation is particularly appropriate because of the timing, and because the EROS office of the Department of the Interior is already coordinating many aspects of the earth observation satellite programs. The consideration by the Congress of the national land use legislation and the general concern for the environment has created greater need for communication and coordination.

4.6 Identification of Environmentally Distressed Areas

It is recommended that areas of great environmental stress or rapid change be identified using high altitude aerial remote sensor data and data from existing Federal programs. Special monitoring programs should be established to provide the basis for intensive governmental efforts to check environmental deterioration and to improve environmental quality in these areas. Such a Federal effort would be analogous to the regional economic development programs of the past decade. It is beyond the scope of this study to make detailed program or legislative recommendations. However, the following description of such a program is appropriate since this recommendation is an essential part of the land use environmental data program recommended by this report.

The analysis of land use data collected by the Federal Government showed, among other things, that successive aggregations of data for

larger geographic regions often obscures intense local problems. For example: The U.S. Department of Agriculture report on land use for 1964^{1/} shows a fairly constant amount of forest between 1950 and 1964 for the nation as a whole. The report states, however, that "substantial acreages of noncommercial forest in the Southern Plains, parts of the West and Alaska, have been cleared or reclassified to other use classes." It is not enough for a land use data system to measure gross national or regional patterns of land use. The system must also identify specific problem areas.

Repetitive high altitude aerial photo coverage of the United States using color, color infrared, and black and white photography could be used for change detection. Color infrared photography is used extensively to detect vegetative stress which is often an indicator of air or water pollution. This sensor is also an essential tool for mapping vegetated areas. Repetitive coverage will detect changes caused by rapidly expanding urban areas, pollution, and the clearing of forests. Areas of rapid change or significant vegetative damage can be identified and more closely investigated.

Black and white photography is used extensively by the Federal Government to map and inventory. It is well suited to identifying and monitoring cultural changes including new construction.

The following two examples illustrate how the data gathering aspects of an Environmentally Distressed Areas Program would work. They cover two categories of land use with which this report is concerned: surface mining, and wetlands.

^{1/} U.S. Department of Agriculture - Major Uses of Land and Water in the United States with Special Reference to Agriculture - Summary for 1964, pg. 6, Table 4.

4.6.0 Surface Mining

Surface mined areas can be easily identified from high altitude aerial photography. (Figure 4.6.0) Color infrared photography has proven to be a particularly useful tool for delineating these areas and for measuring their effects on the environment. Acid mine drainage, a serious pollution problem from abandoned coal mines kills vegetation and this leaves visible scars in mined areas in the form of stressed vegetation, increasing Federal and state concern for the environmental damage caused by surface mining, and requiring reclamation of mined areas. High altitude inventories can be used to measure the areas being mined, to monitor the effectiveness of reclamation efforts, (i.e., are planted areas producing ground cover; erosion occurring) and to direct low altitude and ground investigations. Remote sensing data can supplement existing data from permit applications, ground inspection reports, and water quality information.

Unfortunately, present laws cannot force the reclamation of abandoned mines; and these "orphan mines" represent a significant part of the reclamation problem. Their reclamation will probably become the responsibility of government. Low altitude photography can be used with ground inspection to identify abandoned mines, to assess the environmental damage of individual mines, to make cost estimates of reclamation and to assign reclamation priorities.

Low altitude sensing is also an effective and inexpensive means of monitoring active mines, assessing environmental impact and monitoring compliance with reclamation laws.

LEGEND

110	strip mining,	active	
111	strip mining,	no grading,	0-25% vegetal cover
112	strip mining,	no grading,	25-50% vegetal cover
113	strip mining,	no grading,	50-75% vegetal cover
121	strip mining,	graded,	0-25% vegetal cover
122	strip mining,	graded,	25-50% vegetal cover
123	strip mining,	graded,	50-75% vegetal cover
210	contour mining,	active	
211	contour mined,	no grading,	0-25% vegetal cover
212	contour mined,	no grading,	25-50% vegetal cover
213	contour mined,	no grading,	50-75% vegetal cover
221	contour mined,	graded,	0-25% vegetal cover
222	contour mined,	graded,	25-50% vegetal cover
223	contour mined,	graded,	50-75% vegetal cover
310	Combined strip and contour mining. Not practical to separate.		

A - Coal washing plant
 C - Cemetery
 G - Archeological site

U - Urban area
 HW - Highway right-of-way
 RR - Railway right-of-way

This is a portion of one of EarthSat's operational alphabetical-numerical coding systems for reclamation. Numerical descriptors shown above indicate type of mining, state of grading, and amount of existing vegetative cover. Alphabetical descriptors include some manmade features of special interest to the mining industry. The above data were extracted from a study of a strip mined area in the Midwest.

FIGURE 4.6.0



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SURFACE MINING INVENTORY

EarthSat's photographic analysis of a surface mined area developed from high quality, small scale (1:80,000) black and white photography. The areal extent of the mining has been defined and a classification made as to the surface state and vegetal cover. Additional criteria other than those shown in the attached legend of the descriptors, can be included to meet specific requirements. The data derived can be transferred to base maps of the desired scale and format. More specific data concerning vegetation cover can be derived with color infrared photography.

The use of small scale photography provides a rapid and economical means of inventorying surface mine conditions on a regional basis.

EARTH SATELLITE CORPORATION

1771 N STREET N.W. WASHINGTON D.C. 20036

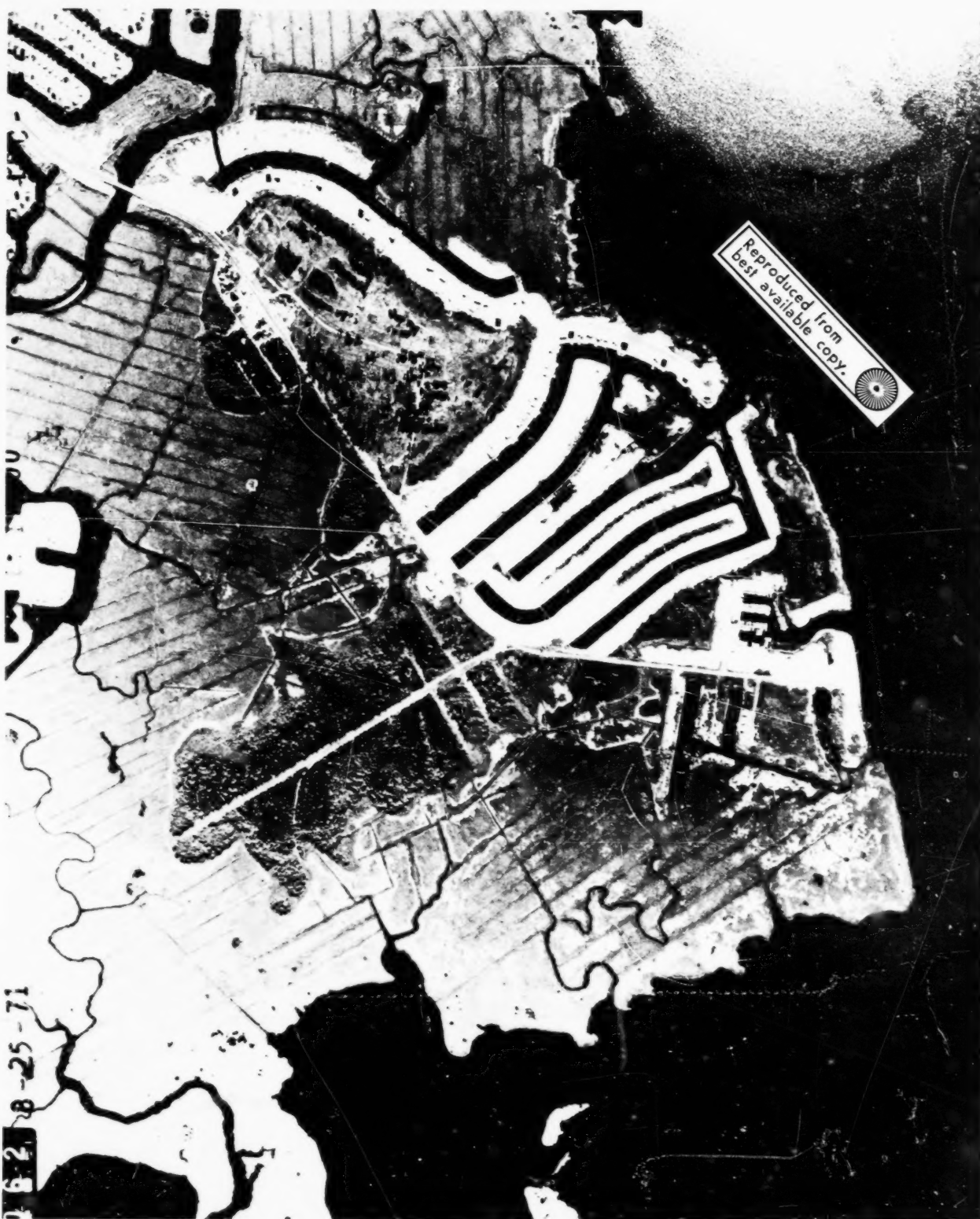
4.6.1 Wetlands

Wetlands are often irreparably altered before the public is aware that they are threatened. Dredges working 24 hours a day can fill thousands of acres of wetlands without detection unless local authorities have large ground inspection forces. The development of recreational communities and industry and water pollution are the principal threats to the nation's wetlands. High altitude sensing can locate those wetlands which are likely to be "developed." The proximity of wetlands to population centers, transportation networks, and the location of recreational opportunities, such as boating or swimming, can be used to identify areas of potential change. In addition, existing residential developments can be delineated, and successive aerial coverage can detect the further expansion of these developments. Many of the cultural features which indicate a wetland area's potential for residential development also apply to industrial development. In addition to these, port facilities, railroads and adjacent industrial sites are useful in assessing the pressure on a particular wetland area. All of these cultural features can be observed on high altitude aerial photography. Changes can be detected and monitored and environmentally distressed areas identified.

Low altitude aerial sensing using principally color infrared photography is being used to monitor changing botanical conditions in wetlands and to detect unauthorized dredging and filling. Having once identified distressed areas with high altitude sensors, low altitude sensing and ground sampling programs can be developed to regularly monitor these areas. (Figure 4.6.1)

Figure 4.6.1 is a low altitude aircraft photo (taken at 6,000 feet) at a scale of 1:12,000. It is a black and white print generated from a color infrared transparency. The photograph shows a part of New Jersey's ditched wetlands which have been destroyed by dredge and fill operations. A "Venice-type" development is being constructed and homes will soon occupy the white-toned areas which consist of dredge spoils removed from the adjacent regularly shaped channels. The New Jersey Department of Environmental Protection is mapping the State's wetlands in order to protect these valuable resources. Color infrared photography is useful for discriminating wetland plant communities thus enabling trained interpreters to distinguish fresh from saline wetlands.

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4.6.2 Conclusion

A dynamic land use data program is essential if that program is to contribute significantly to improving the quality of the nation's environment. Data must be timely and must provide the means for predicting change as well as for assessing what has occurred. Such a system must be capable of isolating areas of unusual interest and of gathering additional data required to support concentrated remedial action.

APPENDICES

GENERAL MATERIAL ON USDA DATA COLLECTION PROGRAMS

The Department of Agriculture collects data on land use with particular reference to agriculture and uses data collected by others. The following is a brief description of the Department's programs which might provide land use data for an environmental quality information system.

The Economic Research Service is not a data collection agency though it is a principal user of land use data within the Department. The ERS prepares the Department's five year analysis of land use, Major Uses of Land and Water in the United States with Special Reference to Agriculture,^{1/} and, in addition, conducts and supports numerous local and regional studies of land use annually.^{2/} The principal sources of data use by the ERS are:

- Bureau of the Census
- Forest Service
- Statistical Reporting Service (USDA)
- Agricultural Stabilization and Conservation Service
- Bureau of Land Management (USDI)
- Geological Survey

A number of other Federal agencies, state and local governments also provide data. The ERS also conducts statewide land use surveys in cooperation with state agricultural agencies and universities. These studies are based upon sampling techniques designed or approved by the Statistical Reporting Service.

The Soil Conservation Service, which is part of the Agricultural Stabilization and Conservation Service, is a major collector and user of land

^{1/} This report originated in its present form in 1945. From similar data, the ERS has estimated major land use back to 1920.

^{2/} For example, see Land Use Change in the Southern Mississippi Alluvial Valley, 1950-1969, Agricultural Economic Report #215.

use data. The SCS is responsible within USDA for providing data for the National Inventory of Soil and Water Conservation Needs.^{3/} The data gathering efforts supporting the 1958 and 1967 inventories are based on a statistical sampling program developed by Iowa State and Cornell Universities. Data on sample units were gathered by local field surveys. Soil surveys were made on each sample area. Statistical laboratories expanded sample data to develop inventory data for entire counties. These data were then analyzed by county committees and adjusted where they varied substantially from known values. The 1967 inventory includes 75% of the non-Federal land area of the contiguous 48 states, 1% of Alaska, and 90% of Hawaii; 63% of the total non-Federal U. S. land area is included.

Soil surveys cover about one-half of the land in farms. They consist of soil survey maps and a description of the conditions found. Field survey teams map soil types and gather samples. Photomosaic base maps are used to produce final maps which are usually published at a scale of 1:20,000.

The Forest Service collects land use data with particular reference to forest land.^{4/} These data are used for productivity estimates, timber resource

^{3/} The most recent inventory was completed in 1967. A number of publications dealing with the data and the procedures followed have been issued by the USDA. See: National Handbook for Updating the Conservation Needs Inventory, USDA, 1966; Basic Statistics National Inventory of Soil and Water Conservation Needs, 1967, USDA Statistical Bulletin #461.

^{4/} Forest Land is defined by the Forest Service as "Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use...Includes chaparral areas in the West and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classed as forest if less than 120 feet in width."

management, policy and legislative purposes at both state and Federal levels of government. The nationwide survey was provided for by the McSweeney-McNary Forest Research Act of 1928. This is a continuing survey with resurveys of states taking place at 8-15 year intervals. The survey covers 775 million acres or about 1/3 of the total U.S. land area. Field surveys for all 50 states were completed in 1963. The survey is conducted through the regional Forest Experiment Stations under the national direction of Forest Survey Branch of the Division of Forest Economics and Marketing Research. Each station uses its own handbooks of procedures though they are subject to the framework established in the National Forest Survey Manual. The forest survey relies on multistage sampling techniques which combine photointerpretation, ground sampling, and automated data processing techniques. These surveys provide areal data including productivity ratings, mortality and disease estimates, and ownership information.

The Statistical Reporting Service collects, compiles, and analyzes data on the current status of agriculture in the U. S. These data cover approximately 50% of the U. S. land area. Probability sampling techniques are used extensively; in the past (beginning for most crops in 1919), estimates were used. The statistics provide data on acreage planted, acreage harvested, yield per acre harvested, and total production. These data are published in numerous local, state and regional reports.

APPENDIX I -- Agricultural Land Use Data

AGRICULTUREFarm Acreage

	<u>by year</u>	<u>no. by size</u>	<u>by states</u>	<u>no. by type</u>
1850	X			
1900	X			
1920	X			
1930	X			
1940	X	X		
1950	X	X		
1954	X	X		
1959		X	X	
1960	X			
1964			X	X
1965	X			
1967	X			
1968	X			

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

	Cropland By Year	Principal Crop Avg.	Principal Crop by States	Corn & Wheat By Year	Avg. Wheat Acreage by States	By States	By Ownership
1839				X			
1850	X			X			
1860	X			X			
1870	X			X			
1880	X			X			
1890	X			X			
1900	X			X			
1910	X			X			
1920	X			X			
1925	X						
1930	X			X			
1935	X						
1939				X			
1940	X			X			
1941				X			
1945	X			X			
1946				X			
1950	X			X			
1951				X			
1954	X			X		X	X
1955				X			
1956				X			

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

ORCHARDS

	<u>Acreage Of Fruits By Year</u>
1929	X
1930	X
1931	X
1932	X
1933	X
1934	X
1935	X
1936	X
1937	X
1938	X
1939	X
1940	X
1941	X
1942	X
1943	X
1944	X
1945	X
1946	X
1947	X

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

APPENDIX II

FORESTRYPublic Ownership

	<u>Nat. Forest By Year</u>	<u>Nat. Forest By States</u>	<u>Forest not in Grazing</u>
1905	X		
1925	X	X	
1930	X		X
1943	X	X	
1945	X		X
1950	X		X
1954	X		X
1957	X		
1963			
1970		X	

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

PRIVATE OWNERSHIP

	<u>Forest and Woodland Not in Grazing by Year</u>
1930	X
1945	X
1950	X
1954	X
1963	

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

REPLANTED AREA

	By Year Nat. Forest	By Region
1906	X	
1933	X	
1964	X	X

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

..

LOSS BY FIRES

	Area Burned By Year	By Ownership	Nat. Forest By Year
1906	X		X
1926	X		X
1930	X		X
1933	X		X
1936	X		
1940	X		
1950	X	X	
1955	X	X	
1956	X		
1959	X		
1960	X	X	
1965	X	X	
1967	X	X	
1968	X	X	
1969	X	X	
1970	X	X	

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

	<u>RECREATION</u>				
	Nat. Park Syst. by Year	State Park Syst. By Year	State Park Syst. by States	Municip. & County By Year	By States
1850	X				
1939	X	X			
1940	X	X		X	
1946	X	X		X	
1950	X	X		X	
1950	X	X			
1955	X	X		X	
1956	X	X			
1960	X	X		X	
1961		X			
1962		X			
1965	X	X	X	X	X
1966	X				
1967	X	X			
1968	X	X			
1969	X	X			
1970	X	X		X	

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

WITHDRAWN

	<u>Nat. Wilderness Preserv. By States</u>	<u>Nat. Wildlife Refuges by States</u>
1964	X	
1967		X

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

Under the U.S. Forest Service the National Forest System Water Supply Watersheds program conducts inventories of watersheds supplying municipal, domestic or industrial water with data on acres within each watershed by National Forest being provided.

The U.S. Department of Agriculture enters into agreements with states to help prepare short and long-term plans for the use of their resources. These River Basin Surveys are usually state sponsored for obtaining information about the agricultural, rural and upstream aspects of their water and related land resources. USDA is primarily concerned with land conditions, land use, the need and potential for development in the upstream watersheds for flood protection, sediment control, fish and wildlife enhancement, water based recreation and storage for irrigation and municipal and industrial water supplies.

The SCS and other agencies assist sponsoring local organizations to develop watershed work plans for the protection and improvement of project-size watersheds. Studies are made to determine conditions within the watershed with respect to floodwater damages, erosion, land conditions and use, fish and wildlife habitat, the availability of water, and pollution sources, particularly with respect to water pollution arising from land runoff. Data needed for the preparation of the watershed plans are developed from technical studies in such fields as hydrology, soils, sediment, forestry, engineering, geology, and biology.

One annual report on the status of conservation practices put out by the SCS shows the total amount of the following conservation practices established on the land at the end of June and the amount of each practice

installed during the fiscal year: Dam, Multiple Purpose (No.); Irrigation Ditch and Canal Lining (Miles); Farm Pond (No.); Floodwater Retarding Structures (No.); Floodway (Miles); Irrigation Storage Reservoirs (No.); Irrigations Systems, Tailwater Recovery (No.); Irrigation Water Management (Acres); Irrigation Pit or Regulating Reservoir (No.); Spring Development (No.); Stream Channel Improvement (Miles) and; Wells (No.).

The National Inventory of Soil and Water Conservation Needs under the SCS was completed as of base year 1958 and published in 1962. Revised data as of base year 1967 are now being prepared for publication in state and national reports. Eight USDA agencies and U.S. Department of Interior's Bureau of Indian Affairs, cooperated in updating the 1958 county-by-county inventory of land use and conservation treatment needs of the nonfederal rural lands, and the watershed projects inventory. Other Federal agencies, representatives of land grant universities, state agencies, and interested county organizations participated on the state and county levels. The land use and treatment needs phase provides soil resource data by five major land uses and estimates of the character and magnitude of the conservation treatments needed to reduce soil losses to tolerable limits and improve grass and forest cover to acceptable levels of potential production. The watershed projects inventory identified the total number of small watersheds in the nation and the number of watersheds considered potentially feasible for project development under the Watershed Protection and Flood Prevention Act, Public Law 566.

FLOOD PLAIN DEVELOPMENT

The principal sources of data on flood plain development within the Federal Government are:

Corps of Engineers

Management Division - There is no way at present to estimate land use in flood plain areas in an economically feasible manner. Data are collected by the Corps for specific areas. No attempt has been made to measure overall acreage on flood plain land use, even on an individual project basis.

USDA - Economic Resources Service

The University of Chicago has completed studies on flood plain management, particularly their Department of Geography.

HUD - Flood Insurance Program Office

Data on flood plain land use is not available at this time but HUD could use such data if they were available. At present, HUD is collecting data on the amount of flood plain land by community and the general kinds of property within flood plain areas.

The Water Resources Council

Their first National Assessment in 1968 describes the water resources of the nation by region. There are no statistics listed for development in flood plain areas. This report states that data are available which provide information on flood magnitude and frequencies for some 300 communities and localities covering some 5,400 square miles of flood-prone areas.

TVA

No data of development - individual studies.

(1) Frequency

Since flood plain land use data is available only on an individual project basis, data is collected with no regular frequency, and on an individual project basis is most probably a one-time study which is not updated at regular intervals.

(2) Purpose

The primary purpose of collecting flood-plain data is for the determination of land use development or change for regulating the use of flood plain areas which are in danger of flood damage. Data developed by the Corps have included the surveying and mapping of flood-plain areas, and hydrology and frequency studies necessary to establish the flood damage potential, flood heights, and the extent of inundation of the areas involved.

(3) Agency Interests

The Corps is concerned with the construction of flood control structures and the minimization of damage in flood-plain areas for the purpose of developing an adequate flood insurance program. USDA and those agencies interested in water resources are concerned with the effects on agriculture and water quality of the areas respectively.

(4) Parameters

Data have not been collected on a systematic basis. There is, therefore, very little consistency among data from different studies, there are few resurveys and present acreage data ignore spatial distributions and relationships.

APPENDIX V

TRANSPORTATION

Highways, Streets, Roads - Mileage

	<u>Rural Roads</u> <u>Municip. States by Year</u>	<u>Rural & Municip.</u> <u>By Government by Year</u>
1904	X	
1930	X	X
1940	X	X
1950	X	X
1955	X	X
1957	X	
1960	X	X
1963	X	X
1964	X	X
1965	X	X
1966	X	X
1967	X	X

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

RAIL FACILITIES - Mileage

	<u>M. Rd. Owned By States</u>	<u>First Track Roads Owned By Year</u>
1930		X
1940	X	X
1950	X	X
1960	X	X
1964		X
1965		X
1966	X	X
1967	X	X

Source: These data are available from a variety of sources, including principally, the quinquennial Census of Agriculture, the decennial Census of Population, National Forest Surveys, and the Census of Transportation.

APPENDIX VI - Urban Land Use

In an earlier review, one of the authors has summarized some of the Urban Areas and Urban Land Use studies with remote sensing imagery:

Urban Area Studies^{1/}

"Three major areas have received attention in urban studies using remote sensors, namely, dwelling unit counts, housing quality, and urban land use. The first two require resolutions on the order of 30 centimetres, the third of about one to two metres.

Dwelling unit estimation

"Information on the number of dwelling units and persons per unit area is vital for many planning studies related to urban population densities, journey-to-work problems, and potential land use changes. Binsell used 1:5,240 aerial ektachrome photographs to estimate the number of dwelling units in selected areas of Chicago. He used methods established by Green and Hadfield, but added refinements such as

'dwelling unit estimation of small multi-unit residences, dwelling unit estimation with a minimum of field checking, application of correction factors to the data of the original study, and photographic key refinement.'

He obtained a total net error of under-estimation of 12.6 per cent in areas covering some 15,000 dwelling units. This was lowered to four per cent and then two per cent by using correction factors, plus improved keys. The final error equals the estimated net error in the United States censuses of 1950 and 1960. These results suggest that the technique should be tried elsewhere and that it may be used to obtain estimates of population density where censuses are not available. However, modifications will be required in each new environment. 'Calibration' of the environment looms as a demanding problem.

Housing quality surveys

"The quality of housing in urban areas is an important aspect of the urban environment. In particular, blighted housing is critical in the ecology of the

^{1/} Simonett, D. S., Urban Area Studies, 1970.

United States city, for such areas are prime candidates for urban renewal and for relocation of major highways and other facilities. Yet existing field enumeration techniques of housing quality by the Bureau of the Census, the American Public Health Association, and by local city agencies are expensive, time-consuming, and open to criticism on the grounds of non-specificity, subjectivity, the non-additive character of parameters, their unsuitability for application to multi-unit structures, and difficulties of understanding and application.

"A series of studies on urban housing quality by Wellar, Moore, Bowden, Mullens, and co-authors, have tested the application of various scales of multiband and colour infrared photography to delineation of housing quality in Chicago and Los Angeles. Mumbower and Donoghue examined conventional black and white photographs of a dozen United States cities for housing parameters. Moore, et al., comment that:

'at a non-rigorous level these studies suggest that data relating to many variables included in current field (housing quality) surveys may be collected with comparable accuracy and considerable savings of time and cost using aerial photography. In the light of the urgency expressed for acquiring data on housing conditions for all large urban areas by federal, state, and local agencies it is imperative that these new techniques be subjected to rigorous scientific testing in order to assess their potential quality in housing surveys.'

"Wellar attempted to discover significant photographic correlates of poor housing quality, using multiband aerial photographs. He developed a procedure he claimed to be rapid, reliable, and an objective source of housing data. He found the most consistent indicators of low-quality housing from the multiband photographs were the presence of litter, garbage, derelict cars, and lumber on weedy, vacant, unlandscaped, crowded lots and the presence of non-residential hazards and nuisances. These criteria were not established by statistical analysis, but by plausible association. Later studies by Mullens and by Moore have provided some statistical varification of Wellar's study.

"Bowden used 1:60,000 scale colour infrared photography to study the quality of residential neighbourhoods in 400 census tracts covering the entire range of income levels and housing types in Los Angeles. He compared the classification

of residential areas based on the 1960 census with that developed by interpreting the C.I.R. imagery obtained in 1967. In another study in Los Angeles, Mullens used a nine-category set of photography based upon a mixture from those developed by Wellar and by Bowden. His categories were dwelling type (single or multi-unit), vegetation quality, litter, vacant land, land use, location, presence of pools and patios, lot and home size, and street quality and character. He correlated these photographic surrogates with census variables using the Kendall Rank Correlation Technique. Consistently a triplet of variables comprising quality of vegetation plus the presence of litter plus the amount of vacant land served as the best indicators of low housing quality and correlated at values up to 0.86 with census tract data, despite the fact that Mullen's sample was in a very homogeneous area of Los Angeles and did not contain as wide a variation in housing quality as tests such as this require. The surrogate approach needs further testing in other cities to establish the limits of its applicability.

"Moore has provided a most useful statistical study on housing characteristics for three study areas of Los Angeles. Patterns of co-variation of housing quality variables at the parcel and block scales were studied along with the potential of photographic sensors for assigning housing to quality classes based on environmental observations only. Principal axis factor analysis showed a structure consistent with the American Public Health Association criteria, and it proved possible to assign quality classes at the block (not parcel) level using observations on environment characteristics only. Whether this situation would apply in other cities is not known. Multiple discriminant function analysis was also applied to the data from the factor analysis. With a much-collapsed matrix the same groupings appeared as with 37 variables devised by the American Public Health Association and the correlations with field enumerated groupings were encouragingly good.

Urban land use mapping

"Urban land use information is needed for a wide range of urban administrative planning and action programmes, and as with data on housing quality, is expensive to obtain, time-consuming, and involves much checking for accuracy. Despite the conventional use of black and white aerial photographs in urban land use mapping many ground surveys are still made, and there have been very few surveys based on balanced use of low and very high altitude

colour and colour infrared aerial photography. Recent studies indicate that much more extensive use could be made of aerial photography and that low, moderate, and high altitude aerial photography are capable of leading to more rapid urban land use mapping than ground techniques.

"Bowden constructed a land use map of west and central Los Angeles using high-altitude (1:60,000) colour infrared photography. The maps were constructed entirely from the imagery and ground checks indicate they were more accurate than those compiled by the Los Angeles County Planning Agency during the same year. Both land use maps were completed in two weeks as compared with several months for the Los Angeles County Planning Agency maps.

"Hannah predicated a study on three basic questions: can the various land uses be identified as well from remote sensing imagery as from a field survey; can accurate measurements for land use be made; and would the time, cost, and accuracy of accomplishing these studies compare favourably with conventional methods? Asheville, North Carolina, was analysed using colour and false colour photography, the results being compared with a ground-based analysis by a consultant firm for the same area at about the same time the imagery was obtained. Field data were compared against the results obtained from the photographic interpretation. Of 1,713 land use parcels identified on the photography, only 26 were mis-interpreted for a total area of 400 hectares. It was estimated that employing photography the procedure through analysis would cost about \$55,000 for Asheville, whereas the conventional field techniques cost \$70,000."

Appendix VII 1/

Black and white simulated satellite imagery of specific scale and quality would provide the following information on land use.

- (1) Cropland: All can be identified.
- (2) Harvested cropland: All generally identifiable, especially if plants are destroyed during harvest and if photos are obtained at the proper season.
- (3) Orchards and vineyards: Identifiable, and assumed to be harvested if maintenance activity level of the planting is satisfactory.
- (4) Crop failures: Would demand timely specialized coverage, which might not be economically feasible.
- (5) Cropland used only for soil improvement: Generally cannot be identified.
- (6) Cultivated summer fallow areas: Generally can be identified in areas where it is the common practice.
- (7) Idle cropland: Identification generally good.
- (8) Cropland pasture: Identification is of questionable accuracy.
- (9) Double cropping: Can be identified only with time-lapse photography (not a scale program).
- (10) Crops for feed vs. human consumption: No basis for decision available.
- (11) Cropland uses by regions: Uses can be summarized on any area basis requested.

1/ Belcher, Hardy, and Phillip, op. cit.

- (12) Pasture and range: Readily identifiable; but determination of intensity of grazing questionable.
- (13) Forest areas that are pastured: Cut areas can be identified; forest range can be identified if generally grazed. Small areas are more difficult to identify. Forest lands that are in plantations, have been cut over, or are in natural growth transition can be identified.
- (14) Changes in land use: If it is possible to identify the land use, then changes in that use can be obtained by sequential coverage.
- (15) Commercial forest areas: Generally identifiable.
- (16) Noncommercial forest areas: A value judgment, but one that can be developed.
- (17) Special uses: Photo interpretation is particularly well adapted to identifying intensive special uses, such as built-up or urban areas and highways. Boundaries of parks and public installations in rural areas are not easily identified.
- (18) Irrigated land areas: Areas with permanent irrigation installations are quite easily indentified; those with portable sprinkler systems are not.

Certain applications of aerial photography to land use classification do not appear to be feasible. Most of these applications center around determination of ownership patterns, specialized land use, or the end use of crop planted. For example, it is not possible to identify soybeans that are produced for oil as opposed to other uses."